The Engineer

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THE ENGINEER

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COAL PROSPECTS

Towards the end of 1950 the National Coal Board published its *Plan for Coal*. It was a detailed document intended to serve as a guide for reconstruction and investment in the coalfields of this country. The plan proposed a balanced programme of capital development which was designed to increase output, improve productivity and reduce costs, by employing men and money where they could produce the best results. The authors of the plan explained at the time that it dealt with "investments, schemes and engineering projects," but these things, they hastened to add, were "only a means to an end, to breathe new life into an old industry, improve the conditions of those who work in it, and help the industry to serve the country better." In the years that have passed since this plan was launched, the National Coal Board has had a hard row to hoe. There have been economic crises and credit squeezes alongside a boom in manufacturing industry, with a consequent expanding fuel consumption, and there has also been a declining manpower in the mines, and, in particular, a shortage of trained engineers for implementing the many schemes of expansion and reconstruction which the Board has initiated. The Board estimated that between 1950 and 1965 (when it was hoped that the programme outlined would be completed) an investment of £635,000,000 would be required, and that deep-mined coal output would by the end of that period have risen to 240,000,000 tons a year. But in presenting its *Plan for Coal* in November, 1950, the Board very wisely said that "as the years go by, much that is intangible and unknown to-day will become established fact and the plan will undergo continuous revision."

Industry and the public generally, as well as the National Coal Board, are now acutely aware that much that was "intangible and unknown"—but not perhaps altogether unexpected—five and a half years ago, has become "established fact." It would be ungenerous to charge the Coal Board with failure because progress with the proposals set out in its plan has been less speedy than might have been hoped, and because deep-mined coal output over the last two years has been declining instead of increasing. The Board has at no time relaxed its efforts to move more quickly towards the fulfilment of its aims; it has, in fact, accomplished much, but not enough. This week the Board has published a revised plan to which it has given the title *Investing in Coal*. It is a document, it is claimed, which records progress and sets out prospects. The principal progress reported is that at the end of last year 167 major reconstruction schemes were completed or in progress, though only twenty of them were actually finished, the remaining 147 being still "in the pipeline." The capital expenditure on major schemes up to the end of last year was £128,000,000, and although so far the return on this investment in the form of coal output may not appear to be very high, the Board gives the assurance that the twenty completed schemes "have yielded satisfactory results." Costs have risen considerably, however, since 1949, and in its latest report the Coal Board has had to break the news that its capital expenditure estimate of £635,000,000 in the fifteen-year period from 1950 must be substituted by a figure of £1,350 million (at 1955 prices). The Board's aim is to spend £1,000 million over the next ten years, and a Bill to augment its borrowing powers is already before Parliament. That considerable additional expenditure, essential though it is, is one of the "prospects" which not only the Coal Board, but the nation, has to face. It would not be unreasonable to expect a bigger "dividend" in the shape of a greater output from the mines than the 230,000,000 tons a year envisaged now by 1965. To reach the figure of 240,000,000 tons quoted in the report, the Board is relying on an annual 10,000,000 tons from opencast working, which, five years ago, it was anticipated would by now be coming to an end. In framing its latest plan the Coal Board has taken the view that atomic energy is "unlikely to affect the situation to any marked degree over the next fifteen years." It has also reaffirmed its intention to utilise "every technical improvement, every engineering advance, that can possibly speed the job of coal production and raise productivity." That is a wise intention. We can only express the hope, as we have expressed it before, that, for the sake of industry and the nation, the National Coal Board will succeed in achieving the objectives at which it is aiming.

DA VINCI LECTURES

Three weeks ago, in a leading article entitled "Boys and Careers," we referred to the "Leonardo da Vinci" lectures for boys, which the Institution of Mechanical Engineers is to present annually at about this time of year. The first group of three lectures was delivered earlier this month and the lectures proved to be excellent examples of their kind. Nor could there be any doubt of the boys' interest. For

they sat silent and absorbed for well over the hour on each occasion. In these circumstances it may seem a little churlish if we prove critical. Yet the risk must be taken because we feel that some of the value of a series of such lectures will be lost if they are continued along the lines on which they started. For excellent as the lectures were, they seemed to us of a kind bound, indeed, to interest boys, but much less likely to influence them towards taking up engineering as a career. Yet, surely the object of the lectures should be so to present engineering that it does appeal to a boy as an attractive career ? A difference in emphasis is all that is needed. Instead of presenting the products of engineering to the boys and describing how they are put together and how they work it would be more appropriate to describe what engineering is and how engineers set to work. Certainly there should be about the lectures nothing of the air of a recruiting speech. But there is amongst parents and also, we think, amongst many teachers, an almost abysmal ignorance about the way engineers work. The idea, very prevalent still, that engineering is " merely " applied science and therefore a low grade of pure science needs to be debunked. So, too, does the idea that engineering is only a kind of craft and not a very clean one at that ! It is desirable, too, to debunk another error, present in many people's minds, that engineering is wholly utilitarian and without any æsthetic content.

It is, of course, one thing to suggest what the aims and objects of a lecture ought to be and quite another to prepare a lecture that fulfils these aims. We can perhaps illustrate the kind of effect which could be created by remarking that Sir Christopher Hinton came near to doing it at one point in his lecture. Having given the physicist's background to the generation of nuclear power, he remarked to the boys that they now had all the information they needed to build their own reactors ! So much, he implied, for the pure scientist's contribution to the design of Calder Hall. One method of presenting a lecture of the kind we have in mind—there must be many others—would be to take some exciting engineering product and to go through the means by which it, or some part of it, was designed and manufactured, bringing out, throughout, where the information came from, how and by whom it was obtained, the kind of factors that influenced design, the art and ingenuity and hard-thinking that had to be exhibited in making inevitable compromises, and the degrees of skill and of organisation involved in manufacture. By this means—and without any suggestion of recruiting—a career as an engineer could be truthfully presented to the boys in all its rich variety of experience ; as something distinct from, and as intellectually, practically, humanly and æsthetically interesting as, any other career they could choose ; and one, furthermore, having plenty of room to accommodate mentalities of all kinds, from those thriving best on academic thought to those gaining immense pleasure from doing something with their hands. Surely, if a greater proportion of boys are to take up engineering in the future it is that subtly persuasive line that should be followed in the lectures rather than one which presents only a more or less popular account of engineering products. One further point occurs to us. The da Vinci lectures are being organised by the Mechanicals. Is it too much to hope that the Civils and the Electricals could be drawn in so that a fuller and more complete presentation of engineering as a career could be achieved ?

SUPERSONIC AIRCRAFT

Last week, at the invitation of the Royal Aeronautical Society, Lt.-Colonel Charles E. Yeager, U.S.A.F., visited this country. Colonel Yeager speaks with authority on the subject of supersonic flight, for he was the first to pilot an aircraft at such speeds, and his achievement of 1650 m.p.h. in December, 1953, has still to be exceeded. So swiftly and soundly have the aircraft constructors of the U.S.A. built upon the lessons of these pioneering flights that, Colonel Yeager tells us, two years ago he flew the Lockheed F.104 " Starfighter " at speeds greater than those now awaiting confirmation as a world record. He added that the level of skill needed to carry out a record attempt was possessed by the majority of contemporary fighter pilots, and that the endurance of that aircraft, an operational fighter, was measured in hours instead of the minutes of research aircraft. There appears to be general agreement that research aircraft can achieve any performance some five years before a service aircraft, so that for U.S. fighters to rival our experimental aircraft is a chastening situation. We cannot agree with those of our contemporaries who resent American writers remarking upon this incongruity. Judging by the columns of their technical journals, they do not hesitate to acknowledge our heavier-than-air altitude record, and consistently laud the Bristol " Olympus " which made it possible, but they can be forgiven for looking askance at an absolute speed record claim which may exist by default on the grounds of military security.

Colonel Yeager himself gives due credit for his country's technological dominance in supersonic flight to the unexampled excellence of the facilities at Edwards Air Force Base, where the flying field is a dry lake whose surface is perfectly flat and hard after each annual rain-storm, and where the sky is cloudless for three hundred and fifty days a year ; the Minister of Supply has also remarked on the value of this immense airfield. The Colonel also recalled that the supersonic research aircraft were initiated during World War II, when the British aircraft industry was exceedingly hard pressed. However, it is by no means the case that Great Britain had no chance of exploring the supersonic regime with, or before, the U.S.A. In 1944, a contract was placed with Miles Aircraft for a research aircraft to penetrate what was called the " sound barrier." When that contract was cancelled in February, 1946, three or four months would have seen the aircraft ready for flight at sub-sonic speeds. Certainly, the development of an after-burner might have presented unforeseen difficulties, and many other obstacles could have frustrated the project—the American " X-1, " we learn, occasionally lost its cockpit canopy at 70,000ft, leaving the pilot dependent on his pressure suit until he could make a hurried return to habitable altitudes—but it is justifiable to believe that 1000 m.p.h. could have been attained in 1947. Since this was an air-burning vehicle, it is unlikely to have been as suitable for extreme performances as the U.S. rocket-propelled aircraft, and the achievement of flight at Mach Number 2 to mark the jubilee of the Wright Brothers' first powered flight would doubtless have belonged to the U.S.A. in any case. Nevertheless, it is arguable that since to-day's service aircraft are turbine-powered, the more valuable information might have been gained from the Miles " M.52."

This country attempted to conduct supersonic flight trials with pilotless aircraft. Colonel Yeager, who made his historic flights wearing a conventional parachute and facing the necessity to clamber out of the cabin in an emergency, did not disguise the fact that he took a considerable risk on these occasions. In the discussion at the meeting of the Society continued emphasis was laid on the point that, to-day, the pilot who loses control, due to a power failure or other contingency, may be doomed, since to eject the pilot into a supersonic airstream may well prove fatal. Even while stressing the need for some safeguard for the airman, the pilots continue with the job : they have courage. But, when we look at the record of British aeronautical research and development, we see that courage is also an essential for those who direct it : they must face the taxpayer who risks his money, the manufacturer who risks his reputation, and the pilot who risks his life. One thing must be clear to the Minister of Supply and his advisers : while they remain responsible for research and are taking decisions as memorable as the cancellation of the Mach 1·5 aircraft we mention, they cannot seek to avoid taking risks.

A Seven Day Journal

Safety of Agricultural Machinery

THE Institution of British Agricultural Engineers has issued a report on an investigation into accidents arising from the use of agricultural machinery and implements. The investigation was made by the Institution's East Anglian centre which gathered detailed information about ninety accidents concerned with farm machinery. Subsequently, particulars of machinery accidents were obtained from the other five local centres of the Institution. From a careful study of the information collected, the conclusion is reached that, if electrical accidents are included, 50 per cent of all fatal accidents on farms are associated with the use, or misuse, of machinery, but only 20 per cent of the non-fatal accidents are concerned with machinery. Of the fatal machinery accidents examined, approximately 60 per cent were concerned with tractors, but the report properly points out that "tractors are more numerous than any other unit of farm equipment, and are used more frequently." The preponderance of tractor accidents cannot, therefore, be interpreted as meaning that tractors need much more careful handling than other machines. A detailed analysis of the accidents surveyed revealed that 58 per cent were caused by failure to take reasonable safety precautions; 31 per cent were attributable to faults in design or lack of guards; 9 per cent were "unavoidable under normal circumstances," and 2 per cent were unclassifiable. The report emphasises the need for adequate training in the use of farm machinery and recommends the preparation of a safety code. A suggested draft for such a code is presented in an appendix to the report. There are also included in the report some recommendations to manufacturers of farm machinery, and recommendations as to safety precautions which it is urged should be enforced on all farm premises. The Institution proposes to circulate the report among Government departments, educational authorities, trade associations and other bodies in any way concerned with the production and use of farm machinery. Moreover, the industrial division of the Royal Society for the Prevention of Accidents has already promised to assist in the preparation of a suitable safety code, and has formed a National Agricultural Safety Committee.

Clean Air

AT a meeting in Birmingham on April 18th, Mr. Arnold Marsh, the director of the National Smoke Abatement Society, said that the Clean Air Bill represented a notable step forward in the long offensive against polluted air. He thought, however, that the main weakness in the Bill was that it did little about the organisation of smoke prevention. Most of the responsibility remained in the hands of the local authorities, and the full value of the Act, Mr. Marsh suggested, would be realised only if there were more inspectors or if more of the time of existing inspectors could be devoted to the subject of clean air. Mr. Marsh went on to say that one of the things the National Smoke Abatement Society had pressed for during the last few years was the prior approval of new fuel-burning plant in industry, so that there would be less chance of smoke nuisance arising afterwards because of poor design and equipment. There had been a marked resistance in British industry over this principle, Mr. Marsh commented, and its acceptance had not yet been wholly achieved. There was now, however, the curious anomaly in the Bill that, prior to the installation of any industrial fuel-burning plant using more than 1 ton of fuel an hour, the firm must notify the local authority, submit its plans, and have them approved in respect of the prevention of grit and dust. In respect of smoke, notification had to be given to the local authority for plant of any size, but approval could not be given except by request! Mr. Marsh added that his Society was very glad the Government had accepted and included in the Bill the proposal to set up, as a statutory body, the Clean Air Council.

100 Years Ago

The Engineer

(APRIL 25, 1856)

"A NEW RUSSIAN FIELD OF ENTERPRISE"

"It is not within our province to speculate on the political events of the war from which we are just respited or reprieved, but there are some circumstances likely to result from an European peace, to which we ask the attention of our readers, as promising a new impetus to engineering speculation and employment... The Russian Emperor's speech at Moscow on the 11th of this month contained this remarkable announcement: 'I have thrown open the ports of Russia to the commerce of the world, the frontiers to the free circulation of foreign produce. Various projects will shortly be communicated to you, the object of which will be to give an impulse to home industry, and in which, I trust, every nobleman will take a share.'

"Among these projects it is understood that railways on a great and comprehensive scale will be included, besides other engineering works of magnitude, and mechanical improvements in all departments of art of the most approved and complete description. Who cannot foresee in these wise projects the development of the real strength of the Russian Empire, and a most extended and remunerative occasion for English talent and practical skill?... The freedom of the Russian ports will do for Russia what was so well done, ages ago, for Holland, and impart an impetus to the commerce of the world of a new and most extended character. The commercial marine of our own, and of all other nations, will receive a mighty development, and the subsidiary arts of ship building and equipment will enjoy a corresponding promotion. In the matter of railways we would enjoin all aspirants of leading engagements to study *economy* of construction. Extended lines will be required for remunerative working through widely-scattered and thinly-populated districts, and cheapness of cost will become the prevailing desideratum."

The British Electrical and Allied Manufacturers' Association

THE forty-fifth annual report of the British Electrical and Allied Manufacturers' Association (BEAMA) was presented at the Association's annual general meeting on April 19th last. Introducing the report, the chairman of the council, Mr. E. H. Ball, commented on some of the trends and events that have influenced the electrical manufacturing industry's progress during the past year. He criticised the fact that "the Government had considered it necessary to intervene in matters vitally affecting industry without sufficient, if any, consultations with industry, and hence full consideration of all the implications." He instanced the handicaps imposed by the Restrictive Practices Bill, the Herbert Committee Report, the credit and capital squeeze and, "last, but perhaps not least," the withdrawal of support from the British Industries Fair. The BEAMA report points out that the British electrical manufacturing industry was built up and based upon a multitude of small companies, many of them family concerns, with anything from fifty to 500 employees. The depression of the 1930s and the increased competition in export markets, from large concerns and combines with correspondingly large resources, taught British manufacturers that only by co-ordinating their individual efforts could they hope to be successful in the fight for exports. This, says the report, is the main reason for the existence of BEAMA and "anything which destroys that co-operation will deal a serious blow to exports and ultimately to the economic welfare of the nation." Against such a background, the report gives details of the electrical manufacturing industry as Great Britain's second largest exporter. In 1955 electrical exports totalled £245,000,000, an increase of 12 per cent over 1954. The main increases were £8,400,000 in cables and wires, £1,700,000 in generators, £900,000 in turbines and £500,000 in motors. The report shows that Britain's main competitors are the U.S.A. and Germany. Germany's formidable challenge is evidenced by the growth in her electrical exports from £105,300,000 in 1953 to £141,300,000 in 1954 and £175,900,000 in 1955. The latter figure is the more remarkable in view of the fact that a greatly increased domestic demand must have weakened Germany's incentives to export.

Revised Plan for Coal

LAST Monday, the National Coal Board published a brochure entitled *Investing in Coal*. It records the progress which has been made in reconstructing the coal industry since the Board issued its *Plan for Coal* in November, 1950. In addition, it presents a revision of that plan necessitated by the changing circumstances which have arisen since it was first drawn up. The brochure starts off by emphasising that the coal industry is the main source of primary fuel in Britain, and that it is going to remain so for a long time, despite the advent of the atomic power reactor. The National Coal Board's task, it is stated, is to raise the output of coal as high as it can to meet the country's increasing need for energy. Success in this task, the Board explains, is governed by the amount of money effectively invested, by the numbers of men and officials employed at all levels, the time they work, and the effort and skill they put into their job with the tools made available to them by an efficient management. In a statement accompanying the brochure, the chairman of the National Coal Board, Mr. James Bowman, said on Monday that the revised plan was more modest in its expectations than the original *Plan for Coal*. Five years ago it had been hoped that the industry might reach a deep-mined coal output of 240,000,000 tons a year by 1965, but it was now thought that such a level could not be reached "much before 1970." Mr. Bowman also referred to the estimate of £635,000,000 as the cost of the projects set out in the original plan, and he pointed out that that figure represented mid-1949 prices. The revised plan, Mr. Bowman said, was estimated to cost about £1350 million over the same period at 1955 prices, of which, so far, about £350,000,000 had been spent. It was aimed to spend £1000 million over the next ten years, but Mr. Bowman added, without investment coal output would inevitably go down.

North of Scotland Hydro-Electric Schemes

No. VII—THE GLEN SHIRA SCHEME—PART II*

(*Concluded from page 368, April 20th*)

The Glen Shira scheme is a peak load development, which will yield about 80,000,000kWh annually from an installed capacity of 45MW. It includes pumped storage, an underground pressure shaft, and a roundhead buttress dam.

CLACHAN power station has been cut out of the rock in the steep hillside of Glen Fyne, so that only its entrance portal is visible (Fig. 8). A tailrace canal leads from it to the River Fyne, a distance of about 1500ft, joining the river about ¼ mile upstream of its outlet into Loch Fyne. It was originally intended to build the power station at the edge of the loch, but the present position suits the pressure shaft design as described in the previous section, and the tailrace is now more favourably positioned to encourage breeding fish to swim up the river.

The layout of the power station may be observed from Fig. 10. It is of reinforced concrete construction with a roof comprising a substantial concrete arch carried mainly on benches excavated in the rock. There is a heavy reinforced concrete arch over the entrance which carries the front edge of the main arch. The total volume of excavation required for the power station was about 15,000 cubic yards. The tailrace tunnel, which is 250ft long, needed a further 6000 cubic yards. On completion of the work, the roof was backfilled to reinstate the surface of the hillside.

Fig. 8—Clachan power station. The tailrace channel is in the foreground and the control building and substation to the left. In the centre the entrance portal of the power station can be seen

The Shira scheme will operate as a unit with the Allt-na-Lairige scheme, 5 miles further up Glen Fyne, and their combined output (100 million kWh annually) will be transmitted to the Inveruglas switching station after local demands have been met. The substation buildings, transformers and administrative offices for this purpose form a group of stone buildings on the edge of Glen Fyne, next to Clachan power station.

The scroll casing of the single Francis turbine set in the power station is embedded in concrete as the diagram shows. The tailrace tunnel has steel arch ribs incorporated in the concrete lining close to the power station, as the rock was of poor quality there. The outer part of the tunnel, which ends in a road bridge, was built by cut-and-cover methods. The first part of the open channel tailrace following it consists, first, of a reinforced concrete channel passing through running sand, for a distance of 900ft, and then of a channel with a concrete invert and side slopes faced with granite pitching for a further 600ft to the River Fyne, where there is a fish heck.

A 132kV transmission line goes over the hill from Clachan to Inveruglas, and 33kV lines on wooden poles connect with the transmission system of the Cowal scheme to the south, with Inveraray and Kintyre to the south-west, and with Dalmally and Oban to the north-west. A local supply to Inveraray was made available before the scheme was started.

PRINCIPAL GENERATING PLANT

The generating plant at Clachan power station consists of one 40MW vertical shaft Francis turbo-generator (Fig. 9). The loading bay and access tunnel are at generator floor level and the auxiliary switchgear is situated on the turbine floor at the same end of the station. The control room is contained in a separate building outside the tunnel. The main generating set runs at 428 r.p.m. and generates at 11kV, 50 c/s and 0·8 power factor. The set gives its maximum efficiency at an output of 32MW when running under 897ft net head.

On account of the high head a low specific speed was chosen for the design of the turbine runner, and shrunk-on labyrinth seals were fitted on the outer periphery of the crown and skirt to minimise leakage.

The turbine has a runaway speed of 760 r.p.m. The turbine bearing consists of a cast iron housing, the two halves of which are bolted together and are in turn bolted to the turbine cover. The bearing housing contains a white-metal-lined cast iron bush grooved for oil circulation. The turbine lubrication system consists of a gear-driven oil pump, together with a motor-driven standby pump, the latter being primarily used for supplying oil during the starting period. The change-over to the main pump is automatic. The oil reservoir is incorporated in the bearing assembly and a separate oil tank is not necessary. The runner is of fabricated construction, the blades being of cast stainless steel while the crown and skirt are made from plate. The steel spiral casing was cast in one piece and incorporates the speed ring.

The inlet valve is a hydraulically operated straight-flow valve, 5ft in diameter and designed to close in emergency against full unbalanced pressure. It is operated by a water servomotor, control being effected by a solenoid-operated distribution valve; the valve cannot be opened until the spiral casing has been completely primed through a by-pass valve. A cylindrical balanced relief valve is branched from the spiral casing and operates in conjunction with the governor to prevent excessive pressure rise on sudden closure of the turbine guide vanes.

The single-acting governor servomotor is controlled by a centrifugal actuator gear driven from the turbine shaft. An emergency overspeed shut-down device is also provided. Oil pressure for governor operation is supplied by an electrically driven pump delivering into a receiver through an unloader valve. A standby oil pump driven by a small Pelton turbine is also provided and comes into operation automatically if the oil pressure falls below certain limits.

Generator.—The generator has a continuous maximum rating of 50MVA and is a two-bracket machine, the upper bracket carrying the pivoted pad thrust and upper guide bearings, and the lower bracket the sleeve type lower guide bearing and the brakes. The bearings are supplied with oil from a pumping set with main and standby pumps and an oil cooler. The stator is supported by a steel barrel mounted on the spiral casing.

Closed-circuit air cooling is provided, the water for the coolers being supplied by a pump which draws from a sump connected to the draft tube. A standby pump is also provided for this duty. A flow relay is provided to give alarm on failure of cooling water supply. Arrangements have been made for bleeding off hot air for station heating. The air is released through adjustable louvres at station floor level, and make-up air is drawn in through filters at the top of the generator casing.

The coupling between the generator and turbine shaft is above the generator lower guide bearing. The main and pilot exciters

* No. I.—"An Introductory Survey" appeared July 14, 1950; No. II.—"The Loch Sloy Project," July 21, August 4, 1950; No. III.—"The Fannich Project," June 8-15, 1951; No. IV.—"The Mullardoch-Fasnakyle-Affric Project," April 11-25, 1952; No. V.—"Some Schemes for Local Supply," October 16-23, 1953; No. VI.—"The Tummel Garry Scheme," September 2-23, 1955

are directly coupled to the generator, and are enclosed and cooled by air by-passed from the alternator cooling system.

The stator frame is formed of welded steel plate. The frame forms a chamber for collecting the air discharged through the core ducts and leads it to the surrounding ventilating duct through holes provided in its periphery. Tubular air coolers are employed, water being circulated through the bore of the tubes and special precautions are taken to prevent water leakage into the air space through faulty tube joints.

The stator has a two-layer diamond winding with two coils per slot, the coils being insulated with class "B" materials throughout. Thermocouples are fitted to indicate the winding and core temperatures and the temperature of the cool air entering and the hot air leaving the machine. The temperature indicator is mounted in the control room. Thermostatically adjusted heaters maintain the temperature of the air within the alternator above dew point when it is not in operation.

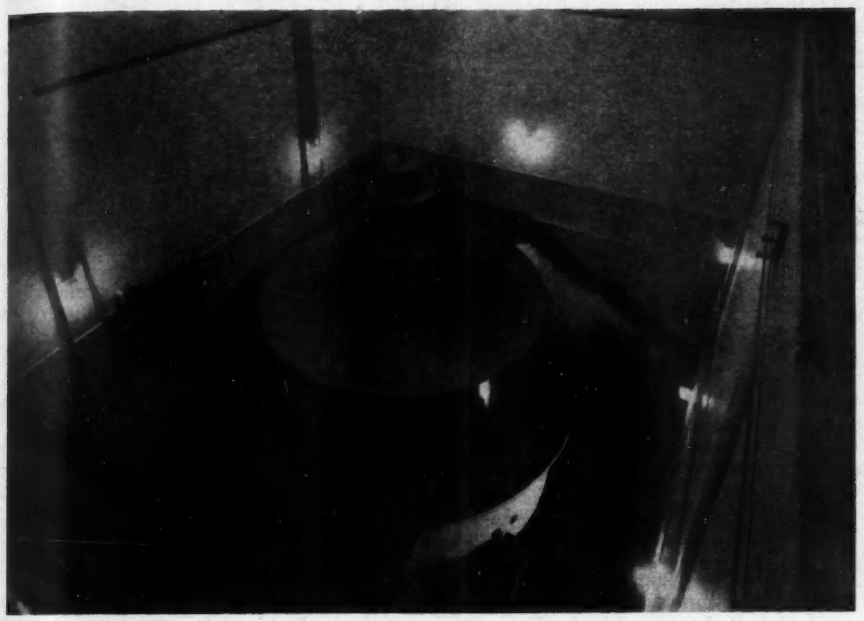


Fig. 9—Interior of Clachan power station, showing the single 40MW generating set

The rotor body is built up of a number of rolled steel plates clamped together and shrunk on to the shaft, the underside being machined and polished to form a track for the brakes. Because of transport limitations the rotor poles were assembled on the dovetailed rotor body at site.

Brakes are mounted on the arms of the lower bracket. Low-pressure air is used for braking and is obtained from the station air compressor through a reducing valve and solenoid-operated brake application valve. For jacking the rotor a high-pressure motor-driven plunger oil pump is used. A limit switch is provided at the top of the exciter shaft, arranged to de-energise the jacking pump motor starter and thus limit the vertical travel of the rotor, so preventing damage.

The lubricating system for the generator bearings includes an oil tank and two motor-driven pumps. For normal operation an a.c. driven pump supplies the bearings with oil through an oil cooler. The other oil pump is d.c. motor driven and is brought into operation by an oil flow relay should the normal supply fail, although the design of the bearings is such that, should the oil supply fail completely, the oil within the bearing would be sufficient to permit operation of the set for a further period.

A spring-loaded centrifugal overspeed device is mounted on the main shaft and has a hand trigger to permit the overspeed device shut-down contacts to be regularly tested.

The excitation system comprises a main and pilot exciter, field rheostats, field suppression cubicle and a beam type automatic voltage regulator which is mounted on the generator control panel in the control room. The regulator is arranged to control the machine voltage during run-up and run-down of the set under automatic control.

Auxiliaries.—Most of the auxiliaries have already been mentioned; they include the governor oil pumps, the cooling water pumps, lubricating oil set, brakes, air compressor and jacking oil pump. There are also two pumps—one main and one standby—in the power station drainage sump operating under floatless water level control to deal with seepage and other drain water. These pumps can also be used for dewatering the draft tube for inspection and maintenance after sealing it from the tail-race with a bulkhead gate.

Automatic Control Equipment.—The machine starting is semi-automatic, i.e. by operating a starting push button on the turbine panel in the power station, or by operating a similar device in the control room, the machine runs up automatically to no-load guide vane opening and normal volts. A signal is given in the control room "ready to synchronise" and the operator then synchronises, closes the circuit breaker and loads the machine in the normal manner. Alarm equipment on the turbine panel gives full indication of the various alarm conditions on the turbo-generator. Grouped alarms are transmitted for display in the control room.

Crane.—The electric overhead travelling crane is a four-motor machine with a main hoist capacity of 150 tons and an auxiliary hoist of 15 tons. The rail span is 47ft 6in and the maximum lift obtainable with the main hoist is 41ft.

Main Switchgear and Transformer.—Fig. 11 shows an abridged key diagram of connections for the Shira scheme. The main switchgear is rated at 11kV, 500MVA and is single busbar, oil-filled, indoor metalclad equipment. An auxiliary board rated at 250MVA supplies the distribution load. The 500MVA and 250MVA switchboards are interconnected through a bus section reactor rated at 4 per cent on 10MVA. The two switchboards are mounted in separate compartments and each has fire protection by automatic CO_2 installations, provided with a second charge under manual control.

Clachan is connected to the Highland grid by a single-circuit 132kV line to Sloy power station. A 50MVA, 132/11kV, ON/OFB transformer connects the line through an 11kV oil circuit breaker to the Clachan main busbar. This transformer has a 20 per cent ON rating to supply the distribution load when Clachan is importing. On-load tap-changing equipment operated from the control room is fitted with tappings arranged for plus 15 per cent to minus 5 per cent in fourteen steps.

The distribution load is supplied by three 33/11kV, ON transformers, one 3·5MVA, one 5MVA and one 7·5MVA. Each transformer is fitted with on-load tap-changing equipment operated from the control room.

Overall protection of the Merz Price type is employed to clear any faults developing on the generator at Clachan, a similar type being employed to protect the generator at Sron Mor and the bus section reactor at Clachan. The busbar protection at Clachan is of the frame leakage type and faults on the 132kV line to Sloy are covered by earth leakage and overcurrent protection with intertripping over post office pilots.

Auxiliary Switchgear.—A unit system supplies the machine auxiliaries, comprising the main governor oil pump, bearing oil pump and cooling water pump. A 11,000/433V, 90kVA unit transformer is solidly connected on the h.v. side to the generator terminals and on the l.v. side through fuses and links to a unit starter board. The starters are of the latched-in type and are normally left closed so that the unit motors run up automatically as the speed and voltage of the machine increases, and are shut down again with the set. The unit transformer also supplies the cooling plant for the main 50MVA transformer, as the OFB cooling is only used when Clachan is generating. Lubricating oil pumps driven by d.c. motors provide oil for the bearings when starting and stopping the sets, and are also standby to the main pumps.

The station auxiliaries are supplied from a 415V common services switchboard rated at 15MVA, and comprising switch fuse gear. The d.c. supply for tripping, closing and control circuits is obtained from a 240V, 250Ah lead-acid battery which is provided with constant voltage and boost charge rectifier equipments. The alarm, indications, supervisory and light current control circuits are supplied from a 50V, 60Ah lead-acid battery with constant-voltage charging equipment.

Control Room.—The Clachan control room is housed in a separate building, together with the main and auxiliary switch-house, some 200 yards from the turbine hall. It contains a light-current control panel and control desk, relay and automatic voltage regulator panels, and a panel for hydraulic indicating equipment for the two dams. The Clachan and Sron Mor machines are automatically started and are controlled and loaded from the desk. Facilities are provided for controlling the Allt-na-Lairige machine from Clachan. Emergency closure of the main tunnel intake gate can also be effected from the control room. An alarm panel is

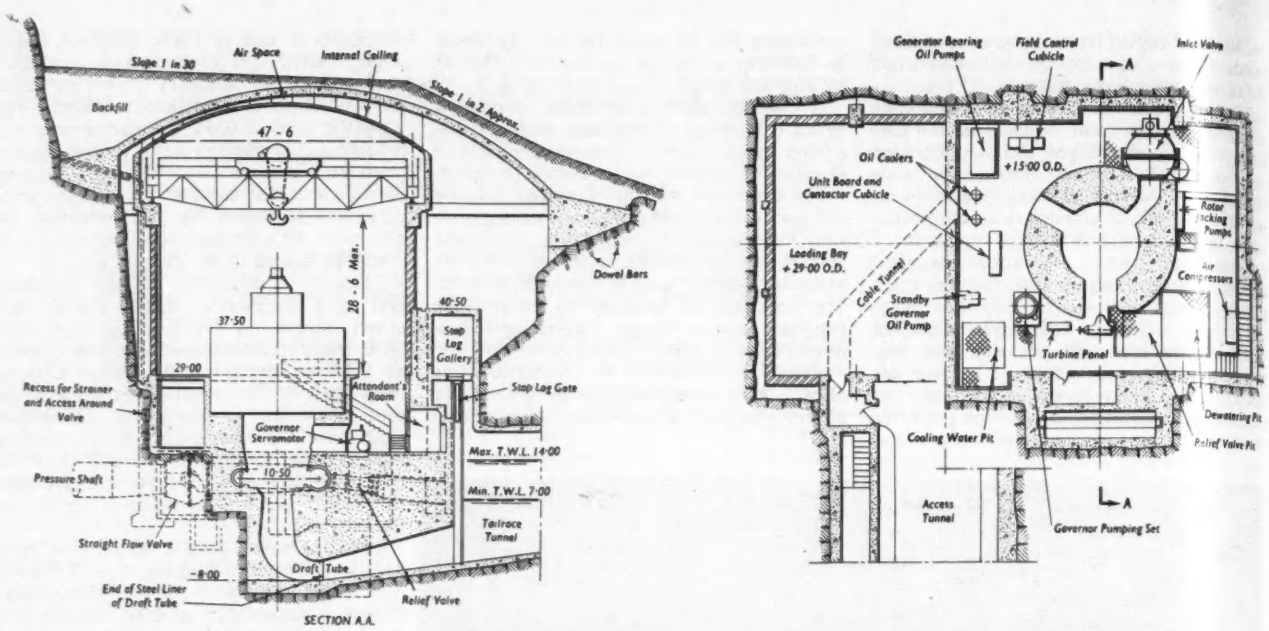


Fig. 10—Clachan power station. The layout of the main generating plant and the "cut and cover" design of the station are shown

provided on the control desk, giving indication of all the electrical faults and grouped indications from Clachan, Sron Mor and Allt-na-Lairige power stations.

Sron Mor Generating and Pumping Plant

The 5MW turbo-generator-pump set at Sron Mor power station acts both as a conventional pumped storage set and to pump water from the lower reservoir to the upper reservoir during times of heavy run-off, as explained in the early part of this article, for at such times the capacity of the lower reservoir is not sufficient to store all the water gathered from the lower catchment area, if the Clachan machine is not running. The set is a horizontal-shaft combined unit consisting of a Francis turbine, an induction generator, a flywheel and a single-entry scroll-cased centrifugal pump coupled solidly to the flywheel. Provision is made for uncoupling the flywheel and pump when generating during dry periods, but the set normally runs coupled. When it is pumping the turbine runs in air, and when generating the pump runs in air. This requirement of dry running of the pump is met by a rigid shaft and casing and by accuracy in machining so that metal contact at impeller neck rings is avoided. A cooling water supply to the neck rings and glands is also provided. The single-entry design and omission of a disengaging coupling enabled the length of the complete machine and therefore the length and cost of the building to be reduced. The purpose of the flywheel is to avoid dangerous pipeline pressures in the event of accidental power failure while pumping. The pump delivers 347 cubic feet per second against a head of 143ft when driven at 297 r.p.m. It must also operate efficiently at discharge heads between 160ft and 100ft.

The set is not governed, the turbine guide vanes being operated by a d.c. electric motor. The machine will be automatically started both for generating and pumping and will be controlled by light-current direct wires from Clachan control room. A brief description of the pump was given in a recent Institution of Mechanical Engineers' paper,* and is reproduced in the following paragraphs.

"The pump's duty is 130,000 gallons per minute against a head of 150ft, and it is driven by a 7000 h.p. motor at a speed of 300 r.p.m. ; it is capable of operating over the head range of 100ft–160ft. Owing to its large size, this pump is constructed more on the lines of a water-turbine casing, having stay vanes to prevent the opening of the horse-shoe section of the volute under pressure. The impeller is of stainless steel and is fitted to the heavy stub shaft of an induction generator/motor which carries the turbine runner on its other end. Owing to the rigid construction the pump can run in air whilst idling, thus avoiding the need for a hydraulic coupling. Previous power storage installations required a coupling to disengage the pump (of the split-casing type) to avoid risk of seizure. The pump casing is made of mild steel and comprises a cast steel speed ring with plate-steel scroll sections. The casing is made in two parts to facilitate transport and maintenance.

"In order to obtain confirmation of the design data on which this large machine is based, a model to one-fifth scale running at five times the speed has been made and tested. With this combination of size and speed, heads, velocities and stresses in the model will represent those of the full-scale machine and, by applying a suitable correction for efficiency based upon change of Reynolds number, an accurate forecast of the full-scale performance can be obtained.

"The full-scale pump requires very special characteristics to enable it to operate over the wide head range of 100ft–160ft with good efficiency and without risk of cavitation. Fig. 12 shows how the test characteristics of the model when stepped up to the full-scale performance agree very closely with the intended characteristics.

"The increase in efficiency from model to prototype was calculated both from Moody formula and Reynolds number analysis as follows :—

$$\frac{1-E}{1-e}=\left(\frac{d}{D}\right)^{\frac{1}{4}}$$

where d is the diameter and e the efficiency of the model ; and D is the diameter and E the efficiency of the full-scale prototype.

"The efficiency increase of a complete range of machines is represented by a Reynolds curve having a varying index, but it is often more convenient on a particular pair of model and prototype to express the efficiency change as the straight line joining two points on a Reynolds curve, that is, by a single constant index which in this case is $\frac{1}{6}$. This index was agreed in the contract.

"On an emergency failure of power the pump would lose speed, the water column would stop and reverse, thus acting as a brake on the pump, stopping it, and finally driving it in reverse as a turbine. It is necessary, therefore, to determine the performance of the unit running forward as an energy destroyer; acting as a restriction to flow at zero speed ; and as a turbine when running in reverse. The turbine characteristics must include operation at no load other than the windage and bearing losses of the induction generator, so as to give data to ensure that no mechanical damage or risk

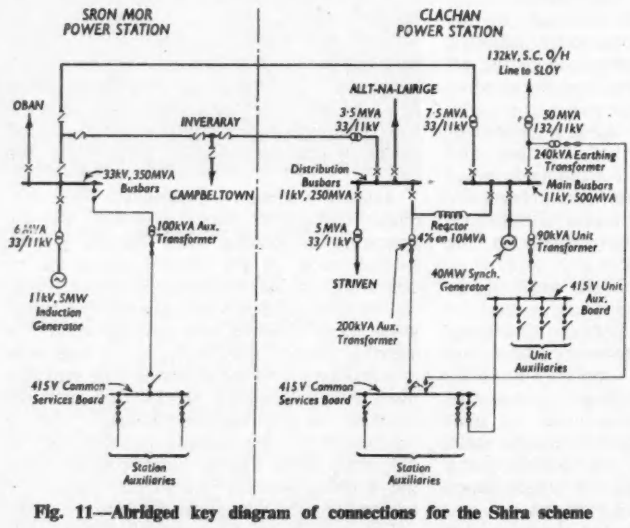


Fig. 11—Abridged key diagram of connections for the Shira scheme

* "Modern Developments in the Use of Large Single-Entry Centrifugal Pumps," by H. H. Anderson, Institution of Mechanical Engineers, October 22, 1954.

of bursting will occur at the reversed runaway speed.

"The energy destruction phase was tested by driving the pump in its normal direction of rotation, and forcing water into what is the pump delivery branch by applying a higher pressure than the pump itself is capable of generating. (The term 'destroy' is usual since no useful work is done: strictly speaking the energy is converted into heat.) In this way the pump received torque energy from its shaft and water energy from the supply to its delivery branch and was able to destroy both these forms of energy. The test therefore involved measuring the power input and the quantity and head input.

"For the transitional point between forward rotation as an energy destroyer and reverse rotation as a turbine, a test was taken

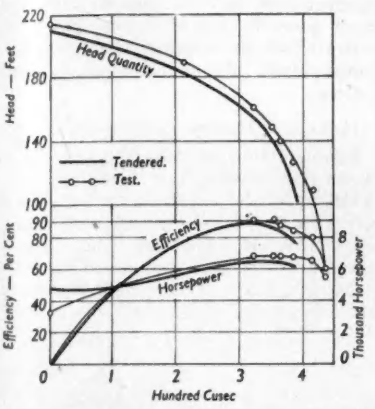


Fig. 12—Characteristics of 7000 h.p. pump at Sron Mor

with the rotor locked under the control of a spring balance. Water was again fed into the delivery branch under pressure, and the static torque and the flow quantity were measured.

"The next stage was to test as a turbine feeding water into the pump delivery branch and permitting the shaft to rotate, driving its motor as an induction generator.

"The water power input was measured by determining quantity and head entering the pump as a turbine, and the power output at the pump shaft was measured by feeding the electrical energy of the motor as induction generator into a suitable measuring system."

The induction generator (which functions as a motor when pumping) is rated at 5000kW, 0·89 power factor, and 11kV, and rotates at a super-synchronous speed of 303 r.p.m. This machine has open-circuit ventilation, the air being drawn axially along the rotor and discharged centrifugally through the stator windings and core into the alternator casing, from where it is discharged through a canopy at the top into the station. The pedestal bearings are oil pressure fed from a bearing lubricating oil tank through an oil cooler. The main lubricating oil pump is mounted on top of the oil tank and is belt-driven from the main shaft. A d.c. motor-driven oil pump is also provided for standby use. An overspeed device and tacho-generator are mounted above and gear driven from the main shaft, and the tacho-generator is connected to a speed indicating instrument mounted on the turbine gauge panel and to a frequency indicating instrument mounted on the main switchgear panel for switching in.

The turbine is a Francis machine operating under a head of 120ft. The turbine gates are controlled directly from a geared motor drive and provision has been made for turbine gate position indication on the turbine panel. To permit dry running of either the turbine or pump, air blowers are provided to depress the tail water level in the turbine draft tube or pump inlet. A cooling water supply is provided for the turbine runner and pump impeller seals and shaft glands during dry running.

The induction generator/motor will be "teed" by a 33/11kV, 6MVA transformer to the 33kV overhead line which runs from Clachan power station across Clachan Hill to Oban, as shown in Fig. 11. This line, which reaches a height of 1810ft, passes between Sron Mor power station and the main dam. The generator/motor is controlled by a 33kV outdoor circuit breaker. A second 33kV oil circuit breaker controls the outgoing feeder to Oban. A 100kVA, 33,000/433V transformer feeds the power station auxiliary switchboard.

The construction of the Glen Shira project has been carried out with a peak labour force of about 800, the estimated cost of the scheme being about £7,000,000 (i.e. £155 per kW). The consulting engineers for the civil engineering aspects of the scheme are Messrs. Babtie, Shaw and Morton, and the electrical and mechanical consultants are Messrs. Merz and McLellan. The architect for the control building was Mr. Hurd. The main civil engineering contractor for the scheme is A. M. Carmichael, Ltd.; the English Electric Company, Ltd., is the main plant contractor, but the pump for Sron Mor was built by Harland Engineering, Ltd., as a subcontract, and the turbines were manufactured by Harland and Wolff, Ltd. Glenfield and Kennedy, Ltd., supplied the sluice gates and valves; the steel pipelines and structural work was done by P. and W. MacLellan, Ltd., Mechans, Ltd., and Stewarts and Lloyds, Ltd.; the main quarry contractor is Keir and Cawder, Ltd.; the cableways at the main dam were supplied by John M. Henderson and Co., Ltd., and the contractor for constructional electricity supplies and Sron Mor substation foundations was Balfour Beatty and Co., Ltd., and for the 132kV line British Insulated Callender's Cables, Ltd.

Other contractors who provided principal items of the plant are as follows: Clachan power station: crane, Sir William Arrol and Co., Ltd.; main and auxiliary switchgear, A. Reyrolle and Co., Ltd.; transformers, British Electric Transformer Company, Ltd., Yorkshire Electric Transformer Company, Ltd., Bruce Peebles and Co., Ltd.; control equipment, Standard Telephones and Cables, Ltd.; main and auxiliary cabling, Scottish Cables, Ltd.; lighting and heating, Drake and Gorham (Contractors), Ltd.; batteries, Chloride Batteries, Ltd. Sron Mor power station: crane, Marshall Fleming and Co., Ltd.; main switchgear, The English Electric Company, Ltd.; auxiliary switchgear, A. Reyrolle and Co., Ltd.; main transformer, Bruce Peebles and Co., Ltd.; station supply transformer, Yorkshire Electric Transformer Company, Ltd.; main and auxiliary cabling, Scottish Cables, Ltd.; supervisory remote control equipment, Standard Telephones and Cables, Ltd.; lighting and heating, James Scott and Co.; portable fire fighting equipment, Fire Armour, Ltd.

Dartford-Purfleet Road Tunnel

It has been announced by the Minister of Transport and Civil Aviation, Mr. Watkinson, that the main contract has been let for the construction of the Dartford–Purfleet road tunnel. The total cost of this project is estimated at more than £10,000,000, of which the contract for driving and lining the tunnel and the construction of its immediate approaches will account for approximately £6,000,000. The tunnel is situated in the Long Reach of the Thames, where the river is half a mile wide; it will be 4700ft long with a single 21ft carriageway, and there will be nearly a third of a mile of cutting between the tunnel portals and the points at which the roadway emerges at ground level (1500ft). The roadway will fall from the tunnel entrances towards the river on gradients of 1 in 28 with a short section practically level underneath the river. At the lowest point in the tunnel the roadway will be 100ft below the high-water level.

As at present authorised by Parliament, the tunnel and its approach roads will make a north-south link about 3¼ miles long between the London–Tilbury Road (A.126) and the London–Rochester Road (A.2), but it is proposed to seek Parliamentary sanction to extend the northern approaches to the Barking–Southend Road (A.13) and to carry the approach road over the A.126 on a viaduct. The approach roads are to be constructed with twin two-lane carriageways. It is expected that the scheme will take about five years to complete and that more than 2,000,000 vehicles will use the tunnel each year.

Messrs. Coode and Partners are the consulting engineers, and that firm has reached an agreement with Messrs. Mott, Hay and Anderson to act as executive engineers; the main contract is let to Edmund Nuttall, Sons and Co. (London), Ltd.

The project is a prewar one, and just before the war the 12ft diameter pilot tunnel was completed, and compressor plant for the main tunnel was installed. The progress of the work was referred to in The Engineer at that time on several occasions, and, in particular, we described the compressor installations for the pilot tunnel in our issue of January 21, 1938.

The tunnel will be iron lined, some 34,000 tons of cast iron being required, and will be shield driven, under compressed air. There will be two ventilation buildings, one near each portal, and the ventilation machinery will be capable of supplying 600,000 cubic feet of fresh air per minute to the tunnel. Instruments situated in the control room will continuously record the state of the atmosphere in the tunnel, the visibility and the number of vehicles passing through. A fire alarm and communications system will be co-ordinated in the control room.

The main tunnel will be circular, the diameter being 28ft 2in inside the lining. The structural lining of the tunnel will consist of flanged cast iron segments, built up in rings, and varying between 1ft 6in and 2ft 6in in width, according to the type of ground to be supported. The flanges of the segments, which will be 14in deep and up to 2½in thick, will be bolted together with 1½in diameter steel bolts. As the cast iron lining is erected it will be grouted under pressure. The joints between the segments will be subsequently caulked with metallic lead.

The tunnel will be driven entirely in water-bearing ground, consisting of the silt and gravel deposited by the river, and the chalk underlying this alluvial material. The main air-compressing plant installed at the working shafts on each side of the river is electrically driven and consists of two sets of three compressors, each with a capactiy of 5000 cubic feet of air per minute and driven by 750 h.p. motors. There are also diesel-operated compressors for use in emergency, and subsidiary plant for supplying the high-pressure air required for pneumatic tools and equipment.

Before the war, two of the shields for the main tunnel were erected in the shield chambers. The two shields will be ready, when their equipment has been overhauled, to be driven under the river, where they will meet and be dismantled upon the completion of that portion of the tunnel, 2800ft in length. After the first shield has moved away from the shield chamber on the Kent side, another shield will be erected in the same chamber and driven in the landward direction towards the tunnel entrance. This shield will be driven up to a caisson, containing ventilation shafts, to be sunk into the mud of the Thames marsh at the site of the ventilation station, within about 300ft of the tunnel portal. Here the third shield will be dismantled and the remaining short length of the tunnel will be constructed in open excavation. A similar process will take place on the Essex side, but as the landward drive here is relatively short, it is possible that a shield will not be used.

Fissured and broken chalk in the under-river section of the tunnel has already received stabilisation treatment carried out from the pilot tunnel. Ground treatment of other strata, including gravels, will probably be carried out in the course of the works. In driving the pilot tunnel, it was expected that air pressures up to 50 lb per square inch might be necessary, but in fact the maximum was 35 lb per square inch.

British Industries Fair

No. II—(*Continued from page* 363, *April 20th*)

BELOW we describe some of the exhibits to be seen at the British Industries Fair which remains open at Olympia, London, and Castle Bromwich, Birmingham, until May 4th.

C. A. Parsons and Co., Ltd.

A completely bladed high-pressure turbine shaft (Fig. 13) for a 60MW, 3000 r.p.m., three-cylinder turbine is shown at Olympia by C. A. Parsons and Co., Ltd., Newcastle upon Tyne. The blading is arranged on a constant mean diameter, necessitating only a single dummy to balance the steam thrust on the blades. The blades at the initial end are to the thrust block—a facility which is generally known as "end tightening." A supplementary seal is provided by a radial fin machined integral with the shroud and set at a reasonably fine clearance from the cylinder bore.

Another exhibit is a mining transformer, 150kVA, three phase, 50 c/s, 3150/600V, delta-star connected, ON cooled, arranged as a transportable substation unit (Fig. 14), and built in accordance with the National Coal Board Specification No. P.108/1954. Tappings of plus and minus 5 and 10 per cent for h.v. and l.v.

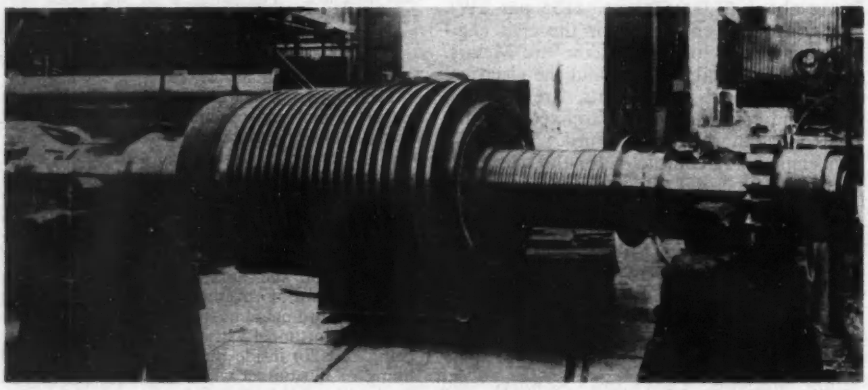


Fig. 13—High-pressure rotor shaft for 60MW steam turbine—Parsons

manufactured with integral roots and shrouds and, for convenience of handling, are formed into short segments which are serrated along the root portion and secured in serrated grooves in the rotor by side locking strips. The shrouds have axially projecting portions which are knife-edged and co-operate with the spacing sections of the adjacent row of stator blades to form a seal. The leakage of steam is thus primarily controlled by an axial clearance which can be set to any desired value with the machine cold and, if desired, adjusted while the machine is running by means of an adjusting gear fitted

variation are provided on the h.v. windings, and a full output tapping at 475V is provided on the l.v. winding, the tappings being accessible through handholes in the tank cover. A Reyrolle draw-out oil-immersed circuit breaker, having a breaking capacity of 25MVA at 3·3kV, is mounted on an adaptor chamber on the h.v. side. This circuit breaker is fitted with three overcurrent trip coils, three inverse time limit dashpots, one direct-acting earth fault trip coil, together with test push button and resistor, and an ammeter. A similar circuit breaker, having a breaking capacity of

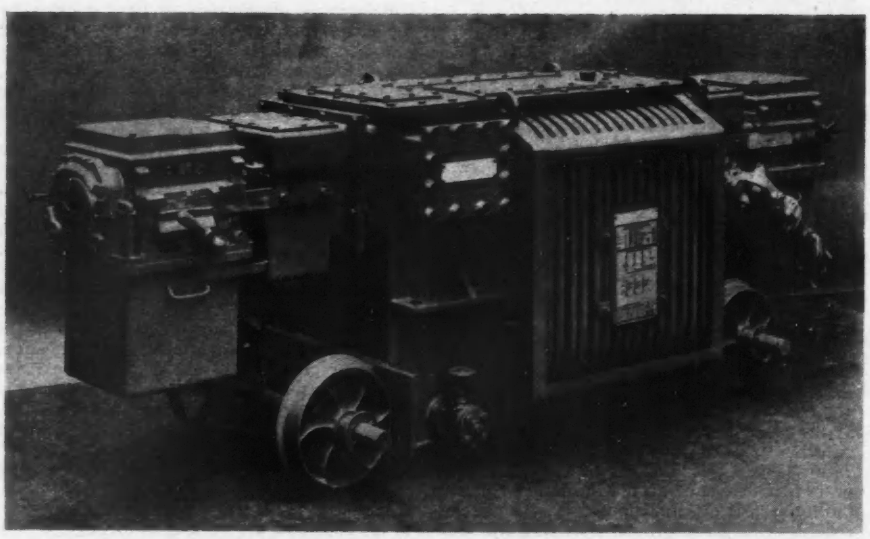


Fig. 14—150kVA mining transformer with circuit breakers arranged as a transportable substation unit—Parsons

5MVA at 440V, fitted with three overcurrent trip coils, three inverse time limit dashpots, voltmeter and an internal earthing device, is mounted on the l.v. side. The neutral point of the l.v. winding is connected to earth through a detachable link, housed in a flameproof type terminal box. The transformer tubes are protected against mechanical damage, and the unit is provided with four flanged wheels which can be arranged to suit any particular rail gauge between 24in and 36in.

Work on hand for nuclear power stations is illustrated on two large display stands. One of these stands will show photographs of plant during erection at Calder Hall "A" station. This plant includes four 23MW turbo-generators with associated condensers and auxiliaries, eight gas circulators, two dump condensers and all the associated gas duct work for two reactors. The second stand gives the list of nuclear power plant orders which the company has received for Calder Hall "B" and Chapelcross power stations.

Hordern, Mason and Edwards, Ltd.

Representative models of a new range of open-front presses are being shown by Hordern, Mason and Edwards, Ltd., Tyburn, Birmingham. These presses are made in seven sizes with capacities from 20 to 100 tons, and, with the exception of the 100-ton machine, all are of inclinable construction. The 55-ton machine is illustrated in Fig. 15,

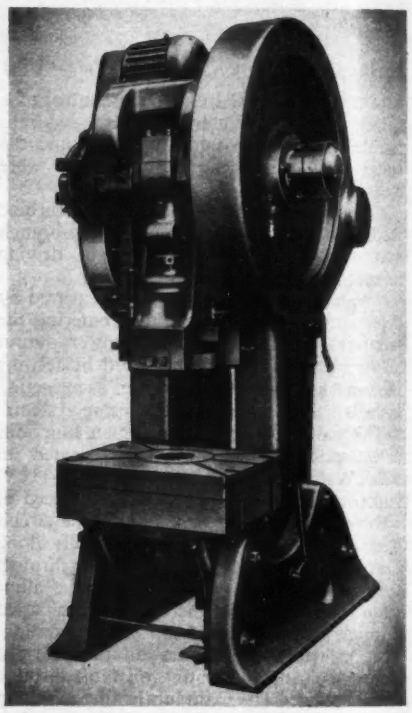


Fig. 15—55-ton open-front inclinable press, with pneumatic slide balance and ratchet adjustment of the slide—Hordern, Mason and Edwards

as typical of the design. It has a rigid cast steel frame which requires no tie bars, and carries an alloy steel crankshaft in heavy-duty bearings. The clutch is designed for easy servicing without need for removing the flywheel, and a non-repeat mechanism prevents repeat strokes when the press is set for single-stroke operation. The slide incorporates a means of ratchet adjustment and is pneumatically balanced in the 75 and 100-ton presses. If required, the pneumatic slide balancing equipment can be fitted on 40-

and 55-ton presses of this design. One of the 20-ton presses will be shown with a recently introduced roll feed attachment, which is integral with a special bedplate fitted in place of the hose bolster plate of the machine. With this attachment double or single roll feeds are available to take stock up to 6in or 9in wide, according to the size of the press. This firm is also showing five double-sided presses and some of these machines will be equipped for the production of typical components.

Foundry Equipment, Ltd.

The machines shown at Castle Bromwich by Foundry Equipment, Ltd., Leighton Buzzard, Beds, include two versions of a fully automatic jolt squeeze, pin-lift, pneumatic moulding machine for boxes from 12in square up to 24in by 18in, and from 14in square to 30in by 21in. In the operating cycle with this machine the half-box is placed on the table and filled from an overhead hopper, and on the operator then pressing the start button all subsequent operations are automatically completed in sequence. The jolt mechanism which first operates can be set to give up to thirty jolts at a maximum jolt load of 500 lb (1000 lb for a larger model machine). At the completion of this operation the head swings into position over the box and its plate is lowered to impart a preset pressure on the mould. The pattern draw, which comes into effect as the squeeze head lifts and swings away, operates in conjunction with a pre-timed vibrator as it gives a slow, even draw over the first part of the stroke, followed by a fast draw for the remainder of the total 9in stroke. The speed and depth of the slow draw stroke can be adjusted.

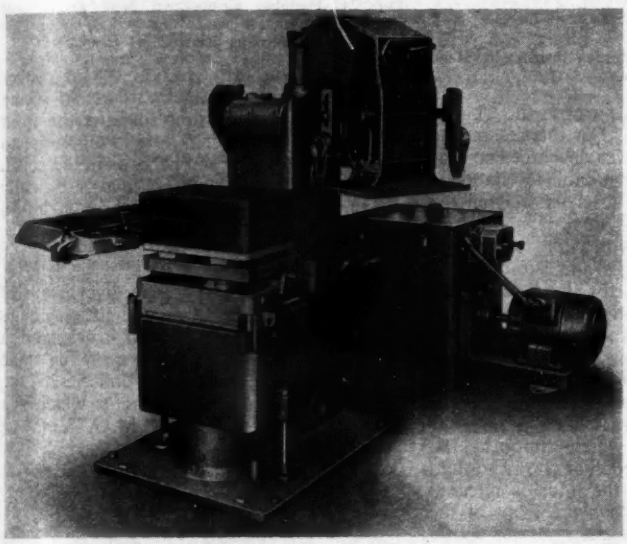


Fig. 16—Hydraulic moulding machine for producing moulds for light shallow castings without the use of moulding boxes, snap or slip flasks—Foundry Equipment

A hydraulic moulding machine is made by the same firm for producing moulds for light shallow castings without the use of moulding boxes, snap or slip flasks. This machine (see Fig. 16) incorporates permanent aluminium top and cast iron bottom boxes, and on it double faced pattern or match plates must be used as the cope and drag are rammed simultaneously. A supply of bottom boards is required. A compact hydraulic pumping set at the rear provides fluid at 750 lb per square inch to the machine, and this power gives a pressure of 60 lb per square inch on the mould. The stroke of the ram can be adjusted between 9in and 12in.

In the sequence of operations the head is swung to the right and the pattern carrier to the left and, after the bottom board has been inserted, sand is fed into the top box or pattern carrier and the bottom box on the ram table. The head and the pattern carrier are then swung into alignment over the bottom box, and on pressure being applied, the cope and drag are rammed simultaneously. In the subsequent drawing operation the top box is suspended from the head by a pair of spring calipers and the pattern plate is retained on the carrier as the bottom box is lowered. The pattern carrier is then swung away and the bottom box raised into contact with the top box, and the boxes are automatically clipped together. In the following stripping operation the locked boxes are drawn down clear of the completed mould, as shown in the illustration, and the head is swung to one side for the mould to be removed on its bottom board. The top box is then transferred to the pattern carrier ready for the next cycle of operations. This machine is made in two sizes for producing 17in by 12in and 18in by 14in moulds.

Also to be seen on the stand of Foundry Equipment, Ltd., is the overhead wire rope conveyor made by its associate firm, Transmission Accessories, Ltd. In this conveyor steel cable segments are used in conjunction with runway trolleys for supporting the carrier units. Each trolley consists of two steel or malleable iron castings bolted together and running on rollers fitted with sealed bearings. A steel insert in the trolley locks the ends of the cable segments through swaged-on terminal blocks to couple the carrier units together.

Ormerod Engineers, Ltd.

One of the exhibits on the D.S.I.R. stand is the " Q.P.-Shirley " metering pump, which is made by Ormerod Engineers, Ltd., Shawclough, Rochdale, Lancs, under licence from Shirley Developments, Ltd. This pump, which was originally developed for feeding a variable controlled quantity of starch solutions to textile sizing machines, is stated to be suited for any other industrial process calling for the controlled transfer of any liquid over a wide range of temperatures or viscosities.

The construction of one form of the pump is shown in the drawing, Fig. 17, and another in Fig. 18. As can be seen, it is essentially a simple reciprocating plunger pump with mechanically operated mushroom inlet and outlet valves. The plunger is driven by a cam, which allows a dwell period at each end of the stroke. Another cam on the main shaft opens and closes the valves through levers *A* and *B* (Fig. 17), push-rods and bridges *C* and *D*. This valve cam is so arranged that valve opening and closing takes place during the dwell period at each end of the plunger stroke.

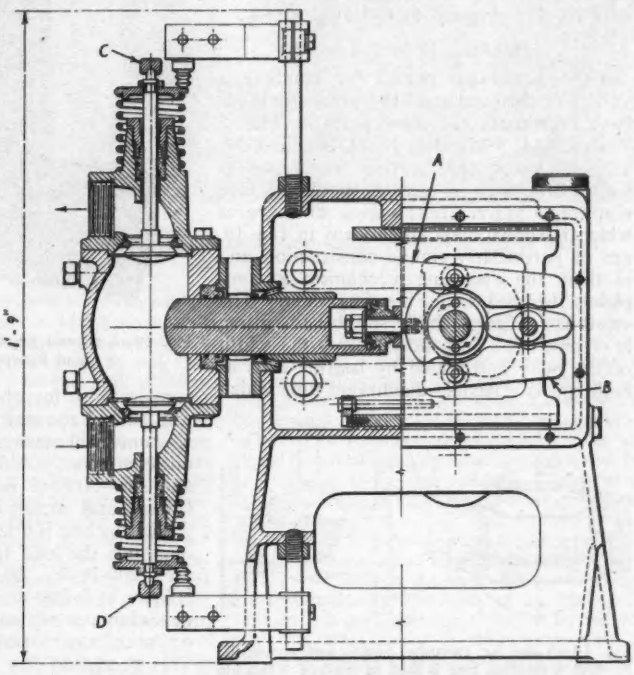


Fig. 17—Arrangement of metering pump for hot viscous liquids—Ormerod

The inlet and outlet ports are of large area, the outlet being directly over the inlet and at the highest point of the pump chamber, so that any air initially entrapped is expelled before liquid. Seals on the ram and on the valve stems prevent leakage of air into the pump, or liquid out of it. There is sufficient resilience in the cylinder and packings to allow the valves to open into a fully charged cylinder at low pressures with the valves

Fig. 18—Cam-operated metering pump for industrial fluids—Ormerod

opposed, and various valve dispositions can be made to suit pressures on either the suction or discharge side with similar operating characteristics.

As the valve timing is such that the inlet and outlet valves can never be open together and the pump plunger is stationary whilst either valve is opening or closing, it will be seen that there is no opportunity for "slip." Opening and closing of the valves during the dwell period of the pump plunger also ensures that there is no plunger movement with both valves closed which could result in loss of effective displacement or hydraulic knock.

Merrill Pumps, Ltd.

Tube diaphragm pumps for handling a variety of chemical and other corrosive fluids have been made for some years by Merrill Pumps, Ltd., Cavendish Road, Sheffield, 11, and this year the firm is exhibiting at Castle Bromwich its recently developed tube diaphragm valve. These valves, one type of which is shown diagrammatically in Fig. 19, are of particularly simple construction and in them the operating mechanism is completely isolated from the line fluid. The valve has a flanged body suitable for fitting in a pipeline. Suspended across the width of the body and sealed by bearing caps at each end is a flexible diaphragm tube which

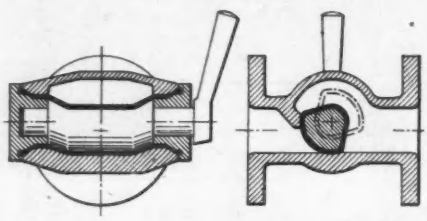


Fig. 19—Valve for corrosive liquids and chemicals, in which a rotating cam is used to displace a flexible tube diaphragm—Merrill

can be of rubber, P.V.C., neoprene or any other material to suit the fluid being handled. Also supported in the bearing caps is a cam-shaped cast iron rotor over which the tube is a free fit. This rotor can be turned by means of a lever or handle to displace and firmly seat the tube over the port in the valve, or to swing it clear and provide a free flow through the valve, as shown in the diagram. A suitable lubricant is packed round the cam to ensure its free rotation in the diaphragm tube and avoid any tendency to "bind" in the opening or closing operation.

The design of the cam rotor is such that it imparts sufficient pressure on the diaphragm to seal the port, and if excessive force is used its turning movement continues—to reopen the valve without damage to the tube or valve body. The pressure drop through these valves is stated to be very low, and they can be set to any required degree of opening without difficulty. In addition to the design shown in the diagram, a similar form of rotor and tube diaphragm construction can be used for multi-port, angle and straightway valves.

W. & T. Avery, Ltd.

The equipment shown at Castle Bromwich by W. & T. Avery, Ltd., Soho Foundry, Birmingham, 40, includes an automatic taring and drum filling scale fitted with electronic control, and the new universal impact testing machine illustrated in Fig. 20. In introducing this machine the makers point out that the Izod impact test has long been established as the standard form of test for measuring the brittleness of metallic materials. More recently the need has arisen for tests at elevated and sub-zero

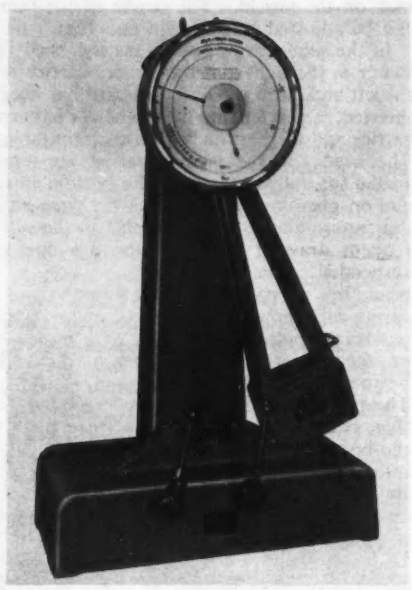


Fig. 20—Universal impact testing machine for Izod and Charpy tests—Avery

temperatures, for which purpose the Charpy test is more convenient. For this reason the new universal machine was developed so that one equipment would be suitable for standard and sub-standard Izod tests as well as for Charpy and impact tension tests.

The machine is fitted with a dual range chart on which the load ranges and sub-divisions are 120ft-lb by 2ft-lb for Izod tests and 30kg-m by 0·2kg-m for the Charpy tests. Its pendulum is mounted on anti-friction bearings on the column carried on rigid cast iron base. This pendulum has two starting positions; the lower one for Izod and the upper one for Charpy tests. The mechanism of a self-resetting toggle latch which supports the pendulum is so designed that the pendulum is not disturbed when the latch is released by operation of a lever on the front of the machine. A loose registering pointer with a hand resetting knob is fitted to the dial of the machine and shows the energy absorbed by the specimens on the clearly marked chart.

For Izod tests the specimen is clamped in a vice with removable gripping dies, and is located by a setting gauge. The striker strikes the specimen at a distance of 22mm above the surface of the gripping dies, and any broken specimens that fall through the grips are delivered to the front of the machine by a chute. For Charpy tests the specimen is supported on a block and positioned by means of a centring gauge. An additional striking edge is provided on the striker for these tests, and it is brought into its effective position by loosening a nut and turning the striker through 180 deg. Additional equipment is supplied to suit the machine for impact tension tests on ¼in gauge diameter specimens screwed ¼in B.S.F. at the ends.

Cengar Universal Tool Company, Ltd.

An air-operated hand saw made by the Cengar Universal Tool Company, Ltd., 89, King Cross Street, Halifax, is another of the pieces of equipment selected by the D.S.I.R. for display on the research stand. This hand saw, which takes standard hack saw blades and weighs only 5½ lb, is illustrated in Fig. 21. It is designed to operate with an 80 lb per square inch air supply and has a 1¼in cutting stroke. The rate of cutting strokes made by the tool is controlled by the setting of a restrictor valve in the lower part of the handle and can be set from 0 to 1100 strokes a minute. A lubricating system is built into the tool and by it oil is picked up by the compressed air and fed to moving parts; if required, the oil-bearing exhaust air can be directed on to the saw blade to lubricate the cut.

To fit a saw blade it is introduced into the tool through the hardened nose-piece, and the relief holes in the front end of the nose-piece accept the set of ½in hacksaw blades

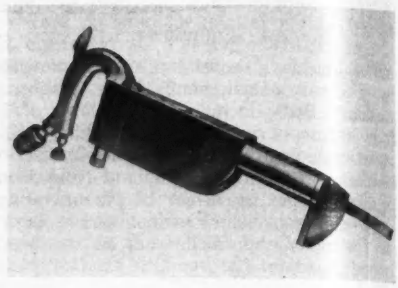


Fig. 21—Portable air-operated hand sawing tool which uses hacksaw blades and makes up to 1100 1¼in strokes per minute—Cengar

so the blade can be used for either cutting upwards or downwards. To secure the blade the round tube forming the front handgrip and silencer is turned clockwise to expose the two grub screw heads in the collet. These two screws are loosened sufficiently for the blade to be inserted through into a split collet and then tightened.

Ransomes, Sims and Jefferies, Ltd.

In addition to a representative group of fork trucks fitted with special lifting equipment, an elevating platform truck and a "T.4" tractor, there is shown on the stand of Ransomes, Sims and Jefferies, Ltd., Ipswich, a new industrial tractor which is a development from the "M.G." crawler

Fig. 22—Small industrial wheeled tractor—Ransomes, Sims and Jefferies

tractor. This "I.T.W." tractor, as it is known, can be seen in Fig. 22.

It is fitted with a 7–8 b.h.p. single-cylinder petrol or vapourising oil engine driving a three-forward and two-reverse speed gear-box through an automatic centrifugal clutch which is controlled by the speed of the flywheel. From the differential the drive is transmitted through gear wheels to the final drive sprockets. Steering and braking is effected through hand-levers which operate brake bands on the drive. In full working order the tractor weighs about 12 cwt, and its respective drawbar pulls in first, second and third gears are 1100 lb, 900 lb and 500 lb.

(To be continued)

Standard Gas Turbine to Burn a Variety of Fuels

By G. B. R. FEILDEN, M.A.,* J. D. THORN, M.A.,† and M. J. KEMPER, M.B.E., B.Sc.‡

At the Institution of Mechanical Engineers on April 6th the development of a 750–1000kW gas turbine for long life and a wide variety of duties was described. Prominent requirements were rapid starting and acceptance of load, and economy in expensive heat-resisting material. We reproduce part of the paper dealing with kinematic construction.

Kinematic Construction

In gas turbine parlance, the word "kinematic" has come to be used to describe any form of mechanical construction which maintains a definite relation between the positions of two or more components independently of temperature variations, and without the development of large stresses in any part of the structure. Such constructions are based upon the application of geometric principles combined with an understanding of the transient temperature distributions which exist during starting and stopping the engine. Amongst the points which require consideration are the following :—

(1) Any material which is exposed to the full variation of gas temperature should be as thin as is consistent with the avoidance of fatigue failures caused by flutter, and there should be no abrupt changes of section.

(2) Where a connection is required between a part which is subject to a large change of temperature and one which is not, a "kinematic" method of attachment is essential.

(3) Where components of thick section are unavoidable (as in the case of the turbine discs) they should be insulated from contact with the hot gases so as to reduce temperature gradients to a minimum, and to allow the maximum time for equalisation of temperature by conduction after the turbine has been started.

The first and last of these principles are self-explanatory, but the second can take many different forms. The choice of the appropriate means of constraint is an exercise in applied geometry somewhat unusual in mechanical engineering, and as the subject has not to our knowledge been discussed extensively, the authors have thought it worth while to include some notes on different methods which have been successfully applied in the gas turbines under consideration. To illustrate the application of these principles, the case of the complete turbine mounting will first be considered, after which the design of three individual components will be examined.

Turbine Mounting.—The turbine machinery has three separate mounting points. These consist of a flexible steel member supporting the inlet end of the compressor, which can be seen in Fig. 1, a hinged mounting near the high pressure turbine inlet, and the rigid attachment of the gearbox casing to the common frame. So far as axial displacements are concerned, the position of the components is fixed in two transverse planes, and any temperature differences which exist between the turbine casings and the frame, result in increasing displacement with distance from these two fixed planes.

Maximum displacements occurring at the front mounting point and at the gas-tight sliding joint in the duct between the high-pressure and low-pressure turbines are 0·090in. and 0·150in. respectively. These figures show that the greater part of the axial thermal expansion in the engine is accommodated internally, so avoiding any substantial movement of the inlet or exhaust ducts. It should also be added that the alignment of the bearings, together with the maintenance of concentricity between the rotors and stators, cannot be affected by distortions occurring in the turbine frame, owing to the relatively flexible method of mounting which has been adopted. Any deflection of the frame in bending or torsion, between the gas generator and power turbine units, can be accommodated by the small radial clearance which is allowed in the mounting of the piston ring seals of the sliding joint in the duct between the high and low-pressure turbines, and, in practice, it is a simple matter to check whether such distortion has occurred by inserting a feeler gauge in the clearance.

High Pressure Turbine Gas Inlet Duct.—The turbine inlet duct, Fig. 3, leads the gases from the combustion chamber exit 1 to the annulus provided by the first row of turbine stator blades. The gases first pass through a right angle elbow duct 2 of converging section. This is located on a pair of swivel pins 3 and fits with a sliding clearance into the opening 6 of the turbine inlet volute 4. The turbine volute 4 is mounted on a stainless steel member 5, the major portion of which is cylindrical with its axis concentric with the turbine shaft. In operation, a considerable temperature gradient exists in the axial portion of this support member, which causes it to become slightly conical with its largest diameter at the end adjacent to the stator blades. Nevertheless, concentricity of the turbine volute is maintained relative to the rotor axis, and no large stresses are developed at the point of attachment of the volute to the support ring, as the temperatures of the two members are nearly the same. When the turbine inlet volute heats up on starting the turbine, its inlet opening 6 moves to the left and this gives rise to a tilting movement in the inlet elbow 2, combined with some axial movement in the sliding joint at the opening 6. These movements can, however, take place unrestrictedly, so that no appreciable stresses are developed.

It should also be added that the outer fabricated mild steel casing of the turbine is provided with a double skin, and a feed of cooling air taken from half-way up the compressor is blown through

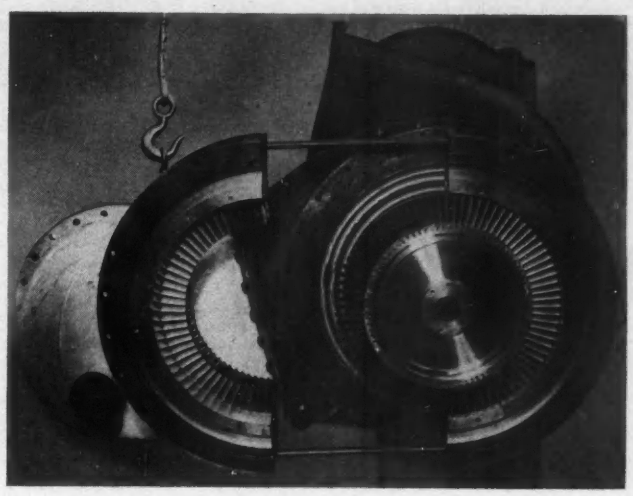


Fig. 2—Kinematic stator construction, showing method of assembly

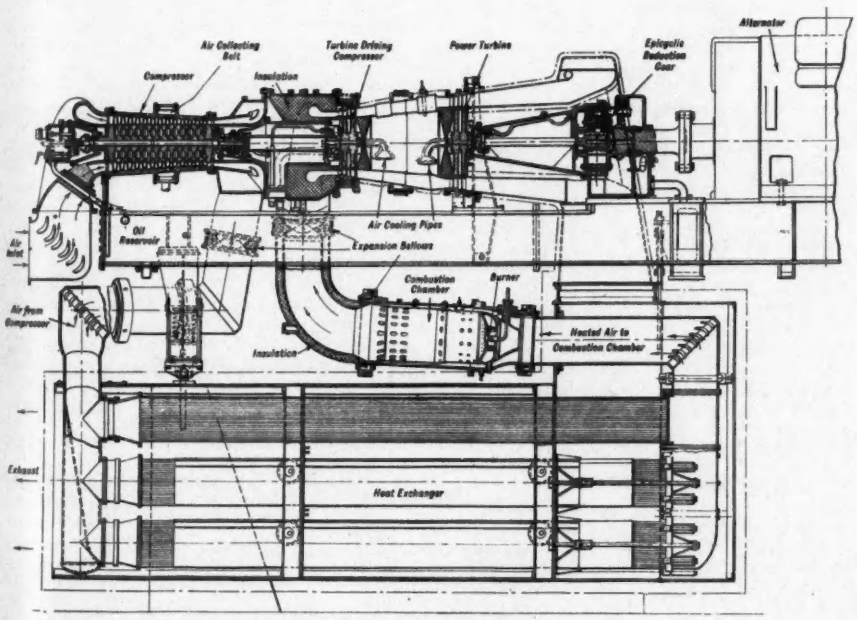
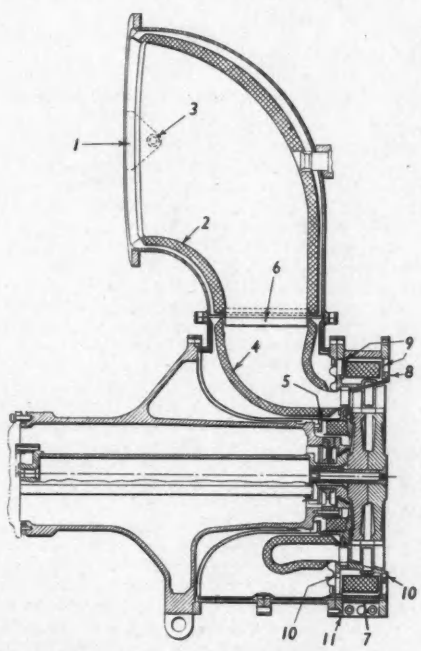


Fig. 1—Sectional arrangement of prototype 750kW recuperative gas turbine



1. Combustion chamber exit
2. Elbow duct
3. Swivel pins
4. Inlet volute
5. Stainless steel support
6. Sliding joint at opening
7. Pressure-carrying member
8. Stator blade segments
9. Radial ribs
10. Dowels
11. Flange joints

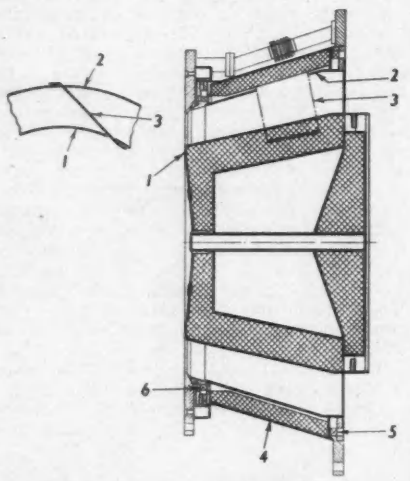
Fig. 3—Construction of high-pressure turbine

* Engineering Director, Ruston and Hornsby, Ltd.
† Chief Engineer, Engine Department, and Chief Research Engineer, Ruston and Hornsby, Ltd.
‡ Deputy Chief Research Engineer, Ruston and Hornsby, Ltd.

the space between the two surfaces when the turbine is running. This cooling air has the dual function of removing the heat which soaks through the lagging, and preventing the development of temperature variations round the casing. The cooling flow used is only 1½ per cent of the total air flow through the turbine, and this is sufficient to prevent the casing temperature rising to more than 400 deg. Fah. (205 deg. Cent.).

Turbine Stator Construction.—The design of the turbine stator assemblies provided great scope for the application of kinematic technique, since these components must withstand very large temperature changes, (amounting to 1300 deg. Fah. (720 deg. Cent.) for the high-pressure turbine), and at the same time maintain concentricity with the rotor to within a few thousandths of an inch. It will be seen that a double skin construction was again adopted, with an outer cooled structural and pressure-carrying member 7 from which the stator blade segments are supported by thin radial ribs 9. Twelve segments have been used for supporting the blades, each of which is held by two dowels 10 which are equally spaced round the circumference.

When the turbine is cold, a clearance of 0·062in is provided between the ends of the segments, as shown in Fig. 2, but this closes up until the ends are practically butting under running conditions. By this method of support and by the adjustment of the rates of heating of the



1. Inner duct
2. Outer duct
3. Tangential spokes
4. Outer casing
5, 6. Radial keys

Fig. 4—Duct between high-pressure and low-pressure turbines

different parts of the rotor and stator system, it has been found possible to run the turbine with a measured blade-tip clearance of 0·030in when hot, and yet avoid a blade rub under any conditions of starting or running.

For assembly or inspection of the turbine, the support member 7 (Fig. 3) has been provided with four flange joints 11, enabling it to be split on either its horizontal or vertical axes. The original design fitted to the prototype turbine had only a horizontal joint and it was found that the two-part support member showed a tendency to "horn in" in the plane of this joint, giving rise to local reductions of clearance. This is a well-known effect which always arises in rings having a discontinuity in their circumference, but distortions were greatly reduced in the production design by the introduction of the additional pair of joints, which also have the advantage of improving the accessibility of the turbine. The dimensional stability of the four-part construction is illustrated by the fact that when one machine was examined after making over 1200 rapid starts, it was found that the blade-tip clearance only varied by a very small amount from its initial value. What is even more important is that the variation developed at an early stage, possibly due to the relief of slight residual stresses in the fabricated support member, and remained stable thereafter.

Duct Between High-Pressure and Low-Pressure Turbines.—This duct acts as a diffuser which reduces the axial velocity of the gas stream from 500ft per second at the outlet of the high-pressure turbine to 350ft per second at the inlet to the output turbine. As shown in Fig. 4, it consists essentially of inner 1 and outer 2 ducts fabricated from $\frac{1}{16}$in thick Nimonic 75 sheet, the inner ducts being supported from the outer by six tangential spokes 3, one of which is illustrated. The outer duct is supported from the cool outer casing 4 by eight radial keys 5 and 6 at each end, which allow free radial movement, while maintaining concentricity notwithstanding the temperature differences.

The design problem in a duct of this type is to maintain concentricity in a structure, the constituent parts of which have very different rates of heating. Being fully immersed in the gas stream, the struts heat up considerably more rapidly than the walls which are only immersed on one side, and are also covered by a boundary of cooler gas. The adoption of tangential spokes 3 provides a fundamental solution to the problems, as they are able to expand along their length, causing the inner element of the duct to rotate very slightly whilst heating up, but maintaining concentricity with the outer member. Under steady running conditions, the temperatures tend to become uniform throughout and the inner and outer ducts assume their original relationships, but should there be any radial inequality of temperature across the annulus, this can be accommodated by very slight flexure of the spokes without the development of large stresses. The only direction in which the spokes are rigid is against axial bending forces, which in the present design amount to a total of 385 lb, due to the pressure force on the inner member of the duct caused by the drop of pressure through the first-stage stator blades of the output turbine.

Automation and Operation at Broadside Filters

By E. W. DENHOLM, M.I.C.E.*

Automatic operation at one of the filtration plants of the Stirlingshire and Falkirk Water Board was explained in a paper presented to the Scottish Section of the Institution of Water Engineers at Glasgow on April 20th. Abstracts from the paper are reproduced here, giving details particularly of the operation of the filters. The original paper also includes notes on filter design, and paragraphs on "Automatic Chemical Regulation," "Automatic Shut-Down and Re-start," "Alarm System," and "Operational Troubles." The filter contractor for the plant was the Candy Filter Company, Ltd.

In many aspects of waterworks, automatic control is not new, and, in the belief that complete automation was not many years ahead, an attempt was made to make the Broadside plant as fully automatic as was felt to be practicable. The plant was, therefore, believed to be the most fully automatic plant constructed at the time of its opening on October 31, 1952. There are a number of plants in various parts of the world incorporating automatic filter washing, mainly after manual selection, but, where the filters do not operate with air scour and have no surface flush, such an arrangement is relatively simple. Other plants incorporate provision for automatic chemical proportioning, or automatic filter flow regulation; or again, they have been arranged to shut down, re-open, or vary the rate of flow, automatically. At Broadside, however, all these operations, including the selection of the filters for washing, are carried out automatically, and, in addition, each operation of the plant is interlinked with a comprehensive system of alarm signals.

Brief Description of Plant

The 40in inlet main divides into two 24in mains controlled by two 24in sluice valves and two 24in float-controlled equilibrium valves. The latter automatically adjust the rate of flow into the plant. The dual entry allows either valve to be isolated for repairs, so permitting normal filtration to continue.

The inlet channel incorporates a screen to collect any foreign material. The water then passes through a Venturi meter and then on to the flash-mixer.

Chemicals for coagulation are introduced into the inlet channel, and the water then enters the flash-mixer chamber through the bottom against a steel spreader plate. Mixing is achieved by drawing water at a rate of 350 g.p.m. from the raw water channel by centrifugal pump and returning it vertically downwards into the mixing chamber on the upper side of the spreader plate, so producing considerable turbulence and effective mixing. There is thus no mechanical equipment, requiring maintenance, operating in the raw water. From the flash-mixer onwards, until the water is returned into the filtered water channel, its procedure on both sides of the plant is identical.

The triple channels between each double row of settling tanks have the raw water channel in the centre and the settled water channels on the outside. The chemically-charged raw water is introduced at the bottoms of the pyramids, thus producing the necessary rotary action for flocculation. The water then rises vertically through a blanket of suspended sludge in which the particles are built up into larger and denser particles.

Settled or clarified water is drawn off evenly into a series of decanting troughs which eliminate short-circuiting and formation of dead patches. The level of the blanket tends to rise, and is controlled by a submerged weir pocket which permits a continuous discharge of sludge into the sludge drains and thence to the sludge lagoons. Heavy sludge can be removed periodically from the hoppers under hydrostatic head, and here again the tanks operate without any mechanical agitating or desludging equipment. These tanks have been very well tried, having been first introduced in India as long ago as 1933.

The twelve filter units are each of 570 square feet of sand area with a capacity of fully 1,050,000 Imperial gallons per day (an actual rate of 77 Imperial gallons per square foot per hour). The water enters each filter through a 12in inlet penstock set in the face of the settled water channel wall and leaves the filters through a 12in module flow-controller, finally entering the filtered water channel under the pipe gallery, where it rejoins the water from the other side of the plant. Sand storage platforms are provided on each side beside the administration building for use if, or when, it becomes necessary to remove sand from any of the filters.

Lime and chlorine entry is at, and beyond, the junction of the main filtered water channel, with the channels from the filters on the side wings. Here also, as on the raw water channels, stop-board grooves are provided to isolate sections of the plant for repairs. The filtered water is finally metered before leaving the administration building.

The handling of chemicals is not such a problem at Broadside as it would be in a softening plant, and it was accordingly decided to handle these mechanically rather than automatically. Automatic handling is more easily arranged with dry-feed chemicals.

The clear water tank is in two compartments of 1,000,000 Imperial gallons each. From the outlet of this storage reservoir a 36in main carries the water into supply.

All pumps, motors, and similar running gear are in duplicate; and, for simplicity in storekeeping and repairs, all of the pumps are identical units, even though some may not be operating at maximum efficiency. The final hydraulic section at a flow of 11 m.g.d. is shown in the first illustration, which also gives a diagrammatic view of the various sections of the plant.

Hydraulic Remote Control

The valves controlling the inlet, upwash, washout, and air on each filter are equipped with double-acting slave cylinders and are operated hydraulically by high-pressure oil. Each filter valve is connected, when required, to the central oil-pressure system through a hydraulic relay which is energised by the solenoid-operated filter bed selector valve in the sequencer.

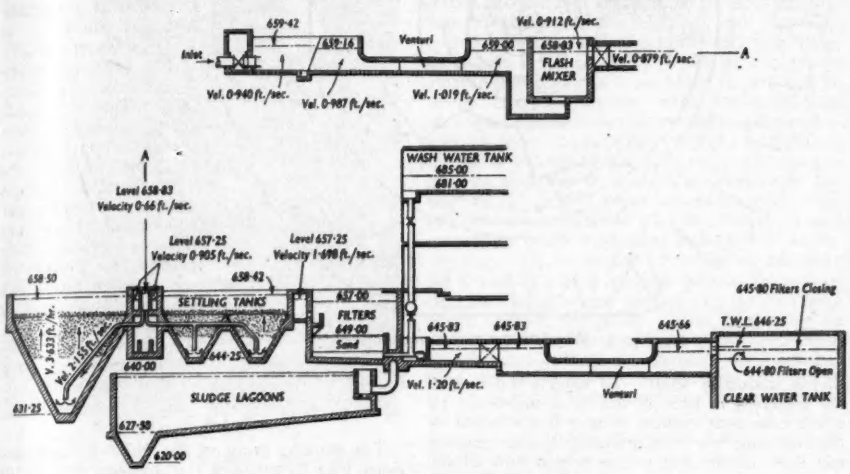
These relays are fed off oil 'bus-mains, which in turn are connected to the central oil-pressure reservoir by solenoid-operated master control-

* Engineer, Stirlingshire and Falkirk Water Board.

valves in the hydraulic cabinet in the switchgear room. The master control-valves (one for each valve function : inlet opening ; inlet closing ; air opening, &c.) are also energised as appropriate by the sequencer. All valves are automatically locked in position unless oil pressure is actually being supplied.

This central cabinet comprises an oil-pressure reservoir, with a nitrogen cushion (air cannot be used as it oxidises the oil), the reservoir being topped up automatically by one of two electrically operated pressure generators, with, in addition, a hand-operated pressure generator for emergency use.

Each filter valve is provided with an electrically operated valve-position transmitter wired to an indicator dial on one of the two side control-tables in the administration hall. The transmitter operating mechanism designed specially for



Principal items in Broadside filtration plant

Broadside comprises a friction roller on the valve spindle working through a cam and push-rod.

Pneumatic control tends to suffer from corrosion troubles due to dampness in the air, and water pressure control has its troubles also from corrosion and freezing. It is difficult, in both, to maintain leak-proof control cocks, and no satisfactory method of locking valves in position appears to have been developed so far. The oil hydraulic system overcomes the shortcomings of the others and does not seem to have replaced them with shortcomings of its own.

Filter Flow Control

The output of each filter is governed by its 12in module automatic flow-controller which can be set to any desired output and which maintains this output constant irrespective of variations in the filtering headloss. It was originally accepted that, although all other filter controls had been taken back to the administration hall, there would still be headstocks along the filter control galleries with spindles down to the pipe gallery for direct setting of the modules.

Following discussion on this point, however, the filter plant contractors developed a remote-control hydraulic jacking system operated from the side control tables in the administration hall adjacent to the automatic sequencer. The remote setting of the modules is carried out by push-button control of a small electrically driven oil-pressure pump through the jacking system ; but, no doubt because of a distrust of anything new, the overriding hand controls have been left on the slow-start tanks for emergency use.

Electrical transmitters at each module are wired to indicating dials for module setting and filter rate of flow. Each filter has, then, on its own section of the side control-tables : a clarity bowl ; a loss-of-head indicator ; a rate-of-flow indicator ; valve-position indicators for inlet, upwash, air, and washout valves ; and a module setting indicator.

Each module works in conjunction with an automatic slow-start control tank, as shown in the second illustration, which functions as follows:

(1)—It closes the module automatically when emptied under the control of the pilot float in the filter when the filter has drained down to the level at which it can be washed.

(2)—It brings the filter slowly into operation after washing over any desired period between five and thirty minutes. The time is pre-set on the time regulating valve controlling the inflow of water to the tank.

(3)—It shuts down the filter automatically and maintains the filter bed waterlogged, should the raw water supply cease for any reason. It is this last function which has been utilised in the automatic shut-down and restart.

Automatic Filter Washing

The arrangement for automatic filter washing, which was first designed to meet the specification on this plant, is probably the plant's most interesting feature. The same arrangement, has, however, been installed since 1952 at six plants in Great Britain, one in Africa, and one in New Zealand.

Instead of a series of conventional cabinets in front of each filter from which valves are operated by remote control, either manually or by electric push-buttons, all the filter washing is controlled from a central sequencer, in front of the meter panel in the administration hall, designed to control the ultimate twenty filters (at present only working on twelve). Each filter has an electrically operated loss-of-head differential transmitter wired to its dial on the side control-table and also a differential pressure switch which sends a signal through to the automatic sequencer when the predetermined headloss at that particular filter has been reached. The number of the filter is then sought out on one of the central indicator dials. That particular filter is then connected to the hydraulic pressure system through its filter-bed selector valve, and the filter-washing process is carried out automatically.

The sequencer makes use of standard automatic telephone relays, switching units, and selectors to General Post Office specification, and special automatic timers which were developed for use with this particular equipment. It carries out the following nine duties :—

(1)—*To wash the filters automatically in the order in which they present themselves for washing.*

If other filters present themselves simultaneously or while one filter is being washed, they are stored in a queue.

The washing sequence is as follows :—

(*a*) The inlet valve closes. The filter then drains down into supply until the water level reaches weir level. The pilot float falls and opens the drain valve, thus emptying the slow start tank and shutting off the module. The module is arranged to close droptight, thus saving a separate sluice valve.

(*b*) The washout valve, in the washout bay, opens and drains down the weir chamber.

(*c*) The air scour valve opens.

(*d*) The air blower starts and scrubs the sand grains for a predetermined time, normally four minutes.

(*e*) The air blower stops.

(*f*) The air scour valve closes.

(*g*) The upwash valve opens by the predetermined amount to pass 3420 g.p.m. through the filter bed. This upwash continues for a predetermined time, normally four minutes.

(*h*) The upwash valve closes.

(*i*) The inlet valve opens and, guided by the deflector plate, water sweeps across the bed and provides a surface flush.

(*j*) The washout valve closes.

(*k*) The filter fills up ; the pilot float rises, closing the drain valve and allowing the slow start tank to fill under the control of its time regulating valve. The module then opens gradually to bring the filter into operation.

(2)—*To provide automatically for a delay of twenty minutes after completion of one filter wash before commencing to wash the next filter, in order to allow the first filter to reach full output.*—In emergency, this delay can be set to two minutes.

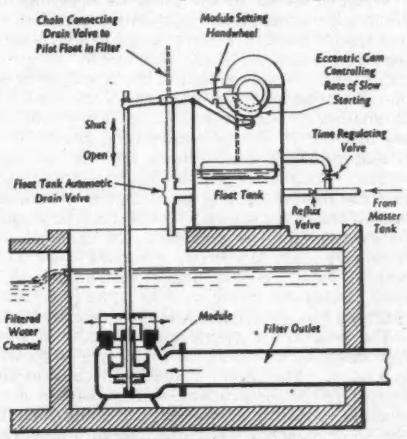
(3)—*To provide means of varying the duration of air scour, upwash, and surface flush through the process timers.*—This is achieved by means of pre-setting switches which can vary the period of time from one minute to ten minutes in each case.

(4)—*To provide for failure of the electricity supply.*—Should the electricity supply fail while a filter is being washed, and should this failure occur during the application of the upwash, the sequencer re-closes the upwash valve before going out of service. When the electricity supply is restored the sequencer then goes back to the commencement of the wash and re-washes the filter. Should the failure occur after the upwash is complete, the sequencer, when the supply once more becomes available, merely carries on with the wash.

(5)—*To provide for manual selection.*—By means of the master control switch and its own manual selector switch, any filter can be brought in for washing manually and left to wash automatically.

(6)—*To provide for manual washing.*—Again by proper positioning of the master control switch, any filter can be selected manually by its own manual selector switch and each of the various filters can be operated under manual control through their own appropriate switches on the sequencer.

(7)—*To provide for alteration in the sequence of washing filters already in the queue.*—To illustrate the flexibility of this arrangement, let



Method of working of module

us assume that filter No. 8 is washing and filters Nos. 12 and 18 are in the priority queue. For some particular reason it may be desirable to wash No. 14 immediately after No. 8. Filter No. 12 is then isolated and cancelled by hand, and No. 14 is selected manually and takes its place on the central indicator dial vacated by No. 12. Filter No. 14 will then wash immediately after No. 8 ; then No. 18 ; and then No. 12—No. 12 automatically retaking a place in the queue after No. 18. The order of washing will now be : Nos. 8, 14, 18, and 12.

(8)—*To give warning of any untoward happening.*—The sequencer is equipped with alarms, both visible and audible, to indicate failure of the oil-pressure system or of the electrical supply, and a master cancelling push-button is embodied

in the top panel, which enables the washing process to be cancelled at any stage.

(9)—*To ensure that each operation is complete before another starts.*—An automatic timer is incorporated to ensure that each valve has reached the end of its travel before the next stage of the washing sequence commences. It was originally expected that the hydraulic valves could take up to 90 seconds for complete opening or complete closing, and the automatic timer was designed to maintain the oil pressure for two minutes. In actual operation it has been found that this is a rather generous allowance, and the time could have been shortened, still leaving an ample safety margin.

Signal lights indicate which filters are working normally and which filter is being washed, while the first two filters in the queue have their numbers indicated on the central indicator dials. The time at which each filter is washed, and the length of time occupied, is recorded on two multi-pen programme recorders on the main panel.

The signal light system operates on 230V a.c. supply. All control relays and solenoids are operated on 50V d.c. from a central battery. Loss of head indicators and the other filter instruments and transmitters operate on 12V d.c. from a separate battery-unit. Both sets of batteries are kept up by automatic trickle-charge.

No attempt has been made to teach the sequencer to talk. This may well be considered one of its main advantages over human control.

Application of Hydrostatic Transmission to Tractors

By H. J. HAMBLIN*

A paper dealing with the application of hydrostatic transmission to tractors was read before the Institution of British Agricultural Engineers, in London, on April 24th. It surveys work with an experimental tractor which has been built, under the author's direction, at the National Institute of Agricultural Engineering. In the opening part of the paper, it is urged that tractors are particularly suitable machines to be driven hydrostatically because they travel at low speeds and do not need to be exceptionally light. Extracts from other parts of the paper are given here.

A Suitable Motor

When it comes to the point of applying in practice the principle of hydrostatic transmission to a tractor there is room for considerable difference of opinion as to the best method of procedure and it would be foolish to claim at present outright superiority for any one of the various alternatives. Nevertheless, it is fairly safe to say that one of the most interesting possibilities is that of using motors built into the driving wheels. This arrangement has the advantage that the motors occupy space that is otherwise unused and that a driven wheel of this type would be as adaptable as possible: for example, it could very easily be steered. From the hydraulics point of view, the advantage of such an arrangement is that the motor is slow running so that churning losses should be low and efficiency high.

The general arrangement of a motor of this type designed to match an 11-36 tyre is shown in Fig. 1. The motor is designed to skid an 11-36 tyre on tarmacadam, with maximum permissible vertical load, without exceeding 3000 lb per square inch. The principle of operation is as follows. The five-cylinder casing is supported on bearings carried on a stationary shaft flange-mounted on the tractor. Part of the stationary shaft is in the form of an eccentric that carries a double-row roller bearing on the outside of which bear white-metalled pads connected to pistons operating in the cylinders. A trapped ball transmits the thrust from each piston through a short column to the associated pad. The pads are retained in contact with the roller bearing by means of a loose retaining ring. Each cylinder is connected by an oil passage to a hole in the outside face of the motor casing, where a matching hard-faced plate is located. Oil passes to and from the cylinders through the stationary shaft, which is hollow, and distribution takes place through a simple, pressure-loaded stationary face valve. When the motor is rotating forwards oil passes down the central tube to the valve and is returned through the annulus between the central tube and the inside of the stationary shaft. To reverse the motor, the direction of flow of the oil is reversed. In either case each cylinder in turn is connected to the incoming flow of oil immediately after passing top dead centre and to the return flow of oil immediately after passing bottom dead centre, the connection being made by the holes terminating the passages to the cylinders passing across arcuate slots in the valve face. The motor is intended to run with the casing full of oil. Excess oil escapes through a passage drilled in the eccentric and along the stationary shaft.

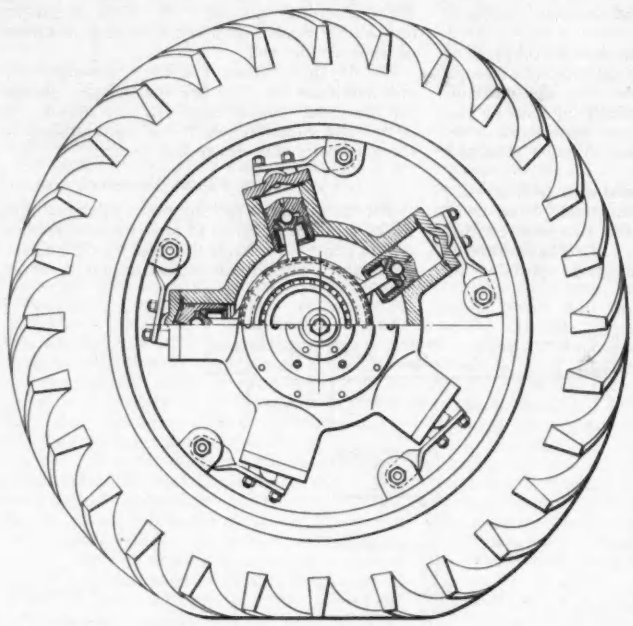


Fig. 1—Wheel motor arrangement

Some details of the design call for comment. The method of introducing the oil through the centre of the supporting shaft was adopted to avoid any high-pressure seal to the atmosphere. Any leakage taking pace from high pressures in the circuit, irrespective of the direction of rotation, is an internal loss, and the only seal to the atmosphere has no greater duty than is commonly required in mechanical transmissions. Considerable use is made of O-rings, not only for sealing around the centre tube, but also in place of gaskets on the cylinder head and the valve cover where the heavily loaded securing bolts make solid gaskets unreliable.

The valve used in this motor is the simplest possible type of face valve. It is an iron casting and is specially faced with hard chromium or other suitable material, but otherwise it represents the simplest and crudest solution of the problem of distributing oil in the motor. The full pressure of the high-pressure side of the circuit is allowed to act on the back of the valve, through the non-return valves shown, and the valve is badly unbalanced, both endways and across (because of the difference in pressure at the two arcuate slots). This simple, but theoretically undesirable, valve was used to see what would happen and, although experimental work is now moving towards examining more complex arrangements, it must be reported that the simple valve can be made to work quite well. The valve is held stationary by a form of Oldham coupling engaging with projections on the end of the stationary shaft. This allows the valve freedom to find its own position on the rotating face.

The general construction of the motor is such that there are no bolts or set screws internally, this being the direct result of an unhappy experience with an earlier motor in which something contrived to work loose inside. The flange of the inner bearing cover plate provides endwise location, shims under the flange being used to adjust the taper roller bearings; the inner race of the double-row roller bearing is located between a shoulder on the stationary shaft and the inner race of the outer taper roller bearing; the loose ring provided to retain the pads is machined from the solid. Attachment to the tractor is by means of a split taper collet engaging with a depression on the stationary shaft and held in a boss integral with the mounting flange. Attachment to the wheel rim is by means of offset brackets attached to the cylinder heads. These brackets are so designed that they can be used, rather like a dished wheel disc, to alter the wheel track.

The bore and stroke of the motor are 3¾in by 2¾in. This means that the maximum piston thrust is about 35,000 lb and the load on the white-metalled pads is about 1·3 tons per square inch. The pistons have a clearance of 0·002in to 0·003in in the cylinder bores, two cast iron rings per piston being used as a seal. The valve face and its mating surface are hand-lapped to a finish of a few micro-inches.

The N.I.A.E. Tractor

The starting point of the N.I.A.E. investigations into hydrostatic transmission was motor design, and the work was limited to this aspect of the problem until experiments had shown very clearly that there was a good chance that a suitable motor could be developed. It was decided to go ahead with building a tractor, although the motors would almost certainly be out of date quite soon and the pump could be little more than a " lash-up " because no suitable commercial pump was available and there were no facilities for testing a prototype.

In the early days it was considered unlikely that a hydrostatic system for a tractor could be designed to use a motor of fixed capacity. It

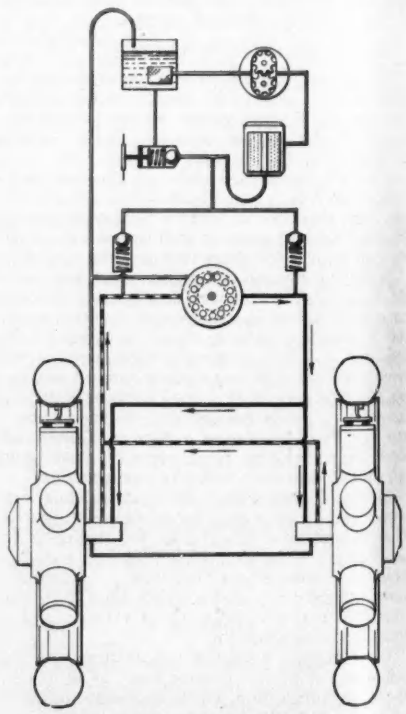


Fig. 2—N.I.A.E. tractor's hydraulic circuit

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was thought that the most successful arrangement would be to make provision for the motor capacity to be halved when required so that, with a given pump of variable output, a basic heavy-duty speed range could be converted into a lighter duty speed range of twice the amount.

The pump is based on a Vickers-Armstrong "VSG" size 6 pump and a number of components from this unit were used in its construction. The standard "VSG" pump could not be used on the tractor because of its size. The modified pump is about 5in shorter and from 3in to 5in less in width and depth measurements at various points. Even so, the modified pump was too large to be accommodated at all comfortably, and stops had to be fitted to restrict the movement of the front axle to avoid the nearside front wheel fouling the pump.

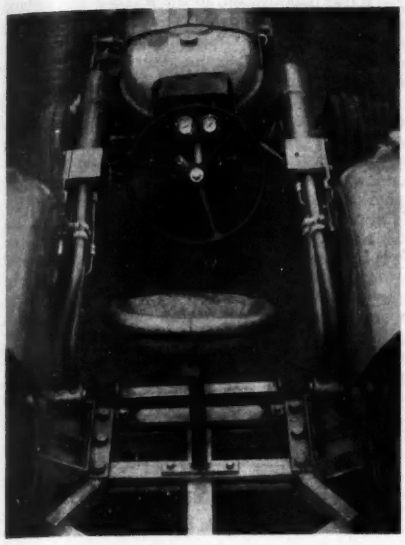


Fig. 3—N.I.A.E. tractor chassis and controls

The Hydraulic Circuit

The hydraulic circuit used is a particular and outstanding example of the increased "know-how" in the field of hydraulics since the early decades of the century. It was suggested by a leading British authority on the application of hydraulics to meet naval requirements and must be acknowledged as having had a considerable influence on the practical success of the tractor. The circuit is shown diagrammatically in Fig. 2. The two motors are connected, in parallel, to the pump in a olosed circuit, i.e. there is a direct, full-flow, connection from pump to motor and from motor to pump, considering each motor separately. A small pump is provided to draw oil from a make-up tank and pump it, through a filter, into the low-pressure side of the main circuit. Excess oil from this boost pump returns to the make-up tank through a relief valve, the pressure setting of the relief valve determining the pressure in the low-pressure side of the main circuit. Either side of the main circuit may be the high-pressure one, depending on whether the tractor is going forwards or backwards and whether it is pulling or over-running, and means have to be provided for the boost pressure to be applied, automatically, to the low-pressure side. This can be done by a pressure-actuated change-over valve, which is what was used on the tractor, or, more simply, by non-return valves as shown in Fig. 2. Oil leaking from the main circuit into the pump and motor casings is allowed to return to the make-up tank.

The main reason for using a boosted circuit is that, provided the boost pump is placed suitably low in relation to the make-up tank and connected to it by means of a sufficiently large pipe, all points in the circuit will be at a pressure above atmospheric and therefore air will not be drawn into the system. The importance of having a large enough pipe connecting the make-up tank to the boost pump needs to be stressed. If this is too small the pressure drop along it may be sufficient to make the pressure at the inlet of the boost pump sub-atmospheric. In this case the system will tend to draw in air and may need to be bled after only a few hours' running. An incidental advantage of boosting the circuit is that it greatly reduces the risk of cavitation at the pump inlet so that the operating conditions for the pump are as favourable as possible. This feature might prove important with a pump running at a higher speed than that used on the tractor. Yet another advantage is that, as the oil circulation through the make-up tank is, of course, only a fraction of the flow in the main circuit, it is practicable for the make-up tank to be only a fraction of the size of a reservoir designed to suit the main circuit flow. This is an obvious practical advantage.

In the circuit used there is no differential regulation of the flow from the pump to the two motors. The flow from the pump comes to a Y-joint and each motor can take the amount it requires. The effect is precisely the same as with a differential gear in a conventional transmission.

Chassis and Controls

The tractor was designed to use as many components as possible of a standard machine. A new Fordson Major diesel-engined tractor was taken as the basis of the design because it could be easily adapted. By interchanging the conventional front axle and radius rod locations the power unit has been brought forward approximately to a point of balance about the front wheels. The blank nearside of the engine has been utilised as a location for the N.I.A.E. pump, a chain drive being taken from the crankshaft. A plate bolted to the flywheel housing flange carries the chain drive to the pump and the various components of the boost circuit, including the boost pump, which is mounted on the end of the crankshaft and driven direct from it. The remainder of the tractor consists of two tubular side members leading to a fabricated and bolted rear frame. The oil pipes to the motors pass through the tubular side members as can be seen in Fig. 3. There are three pipes connected to each motor, two to carry the main flow of oil, and a third, much smaller, one to carry the leakage oil to the make-up tank.

The free space available with this form of construction is clearly shown in Fig. 3, but it must not be forgotten that this is a bare tractor without power take-off, belt pulley, hydraulic lift, three-point linkage, power-assisted steering or parking brake. The two controls are placed within easy reach of the driver, but out of the way, one on each side. The one on the driver's right controls the engine governor. The one on the left controls the pump tilting box; the connecting-rod passes through the nearside tubular side member. When the pump control lever is in the mid-position the tractor is stationary, when it is moved forward the tractor moves forward, and when it is moved back from the mid-position the tractor moves backwards.

A standard hydraulic lift and three-point linkage can be fitted to the tractor when required. This can be seen in Fig. 4, which also, incidentally, shows the make-up tank, mounted on the offside of the tractor engine. The lift assembly incorporates a power take-off shaft and is driven by means of a shaft coupled to the rear of the main pump drive shaft. The assembly is a complete unit which is only fitted when mounted equipment is to be used. When the tractor is pulling a trailer or trailed implement the lift assembly is removed so that the operator has the advantage of being able to mount and dismount with ease.

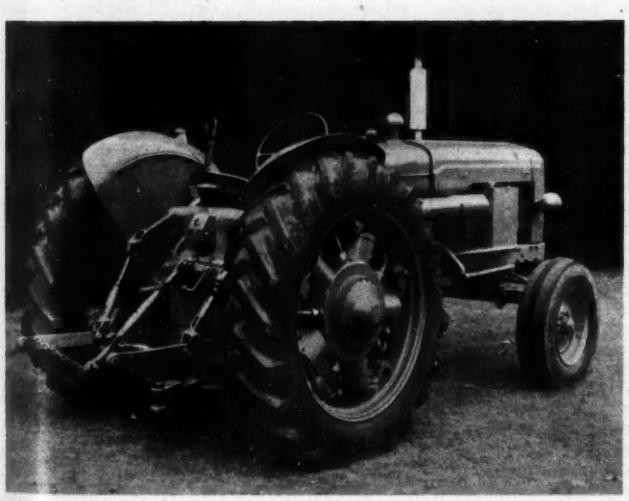


Fig. 4—N.I.A.E. tractor equipped with three-point linkage

Motor and Tractor Performance

Practical operation of the N.I.A.E. tractor has shown that the theoretical advantages of a hydrostatic transmission work out most impressively in practice. As long as the hydraulic circuit is kept free of air the control is very positive, extremely effective and utterly simple to use. There is no trouble from the cyclical speed variation in the motor which is absolutely unnoticeable when driving the tractor, even at a speed as low as one-tenth mile per hour. It has been found that both experienced and inexperienced drivers adapt themselves to the tractor in a matter of minutes and it has been interesting to note how an experienced driver almost immediately starts to take advantage of the possibility of changing speed while on the move, with the result that he achieves a remarkably high rate of work, particularly on a job such as ploughing a field where the soil resistance is very variable. One feature of the tractor that often gives rise to favourable comment is that, as long as the engine is running, brakes are not required so that the operator has no need to perform two operations when stopping, even with a load behind.

Operating a hydrostatically propelled tractor, in summer or winter, has been found in practice not to present any difficulty. It might be thought that a circuit with an oil circulation of over 60 gallons per minute would be difficult to keep oil-tight in practical operation, but experience has shown that this is not so. The importance of keeping the circuit free from air cannot be too strongly stressed; if air is allowed to get into the circuit the transmission becomes noisy, inefficient and lacking in positive response to the control. Keeping free of air is largely a matter of design: the design of the circuit must be such that it can be quickly and fully filled with oil and, also, such that there is no tendency to draw in air. The latter point has already been mentioned in describing the circuit. The former is a matter of arranging the piping suitably and working out a procedure for filling with adequate provision for bleeding-off trapped air.

A complete account of the development and experimental work associated with the N.I.A.E. hydraulic motors will be published when a suitable stage in the work has been reached. Experiments have shown that there is no difficulty in obtaining an overall motor efficiency of over 85 per cent at a speed corresponding to 3 m.p.h., over a range of pressures from 400 lb to 2000 lb per square inch. A peak efficiency of not less than 90 per cent is not difficult to obtain; a value has been recorded of 94·2 per cent at 1000 lb and 1200 lb per square inch, with a Mk. 1 : 11-36 motor (as used on the tractor), but this was with an oil that would probably be a trifle heavy for use with a high-speed pump such as is likely to be developed for use on a tractor. The motor speed corresponding to 3 m.p.h. is 18 r.p.m. and experiments at speeds up to 120 r.p.m. have shown that the slow speed is an important factor contributing towards high efficiency.

Results at higher speeds seem to indicate that

a built-in wheel motor is greatly to be preferred, on the grounds of efficiency, to the use of a smaller higher-speed motor with a final gear reduction to the driving wheel ; but it must be remembered that the wheel motor is not designed to run at high speed, so that a fair comparison of the two propositions cannot be made on the evidence so far available. The most important factors influencing the performance of the wheel motor described appear to be : the material of the valve face, the oil used, the temperature of the oil and the speed of the motor. Other variables include the piston clearance and, affecting this, the desirable range of operating pressures. Altogether, a complete investigation into motor performance involves quite a number of factors and the work on this subject must necessarily be protracted ; but the results so far obtained show quite clearly that a slow-speed motor of reasonable efficiency can be contrived. The biggest query is whether the simple type of valve described is entirely suitable ; the provisional assessment is that commercial development engineers would be wise to think in terms of a better balanced arrangement.

The main purpose of building a tractor was to gain practical experience in operating and maintaining a hydrostatically propelled machine and formal testing of the tractor has not figured at all prominently in the programme of work on hydraulics. In any case, a complete test over the full range of pulls normally associated with this size of tractor cannot be made because of the limitations of the N.I.A.E. pump which is not capable of operating at pressures greater than 1300 lb per square inch, corresponding to about 3200 lb drawbar pull on tarmacadam. (The " VSG " pump on which it is based is rated to work at 1000 lb per square inch ; the limiting factor in the case of the N.I.A.E. pump is the strength of the tilting strap.) Nevertheless, some measurements have been made of drawbar horsepower and fuel consumption on tarmacadam and the results are shown in Fig. 5 superimposed on those of an official test of a Fordson " Major " tractor.

The lowest fuel consumption of the N.I.A.E. tractor was 0·536 pint per drawbar horsepower-hour. This compares quite favourably with the official test figure of 0·530 pint per drawbar horse power-hour for the standard tractor and indicates that the overall transmission efficiency is reasonably good. The importance of arriving at a high efficiency with the hydraulic system perhaps needs a word of explanation ; it is not only a question of fuel economy. It is true that an inefficient transmission leads to a higher fuel consumption at a given load and speed, but it is quite possible that the farmer might be prepared to accept this and, in any case, he might find that the greater versatility of the stepless transmission enables him to load his engine better and show no overall wastage of fuel in terms of gallons per acre. A much more serious consideration is that the wasted energy in an inefficient transmission will appear as heat and, if special provision has to be made to dissipate this heat, an appreciable increase in the cost and complexity of the tractor is likely to result.

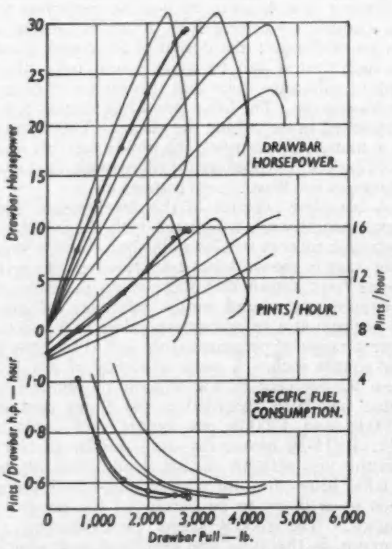


Fig. 5—Results of preliminary drawbar tests. The heavy lines show the N.I.A.E. tractor's performance ; the others are taken from a test report on the New Fordson Major diesel

Most conventional tractor transmissions have an efficiency in the range 90±3 per cent. To be successfully applied to small and medium-powered tractors a hydrostatic system needs to have a peak efficiency approaching the lower end of this range. A hydrostatic system should be capable of dissipating heat very effectively because the total surface available for heat dissipation can be fairly extensive and the continual flow of oil should help to distribute the heat evenly, but an efficiency much below that normally obtained on tractors is bound to lead to the use of special oil coolers. This would be acceptable on large tractors—it is, of course, normal practice when a hydro-kinetic torque converter is used in a large tracklayer—but it might very well prove a deciding factor against the use of a hydrostatic transmission for smaller machines. The results shown in Fig. 5 appear to justify a little cautious optimism on the point.

Possible Influence on Tractor Development

It is interesting to speculate how the adoption of a hydrostatic transmission might influence tractor development. Presumably there would be a tendency, with agricultural wheeled tractors, to move towards some form of skeleton construction and the obvious corollary is that special equipment, such as hydraulic lifts and belt pulleys, would be made to be mounted and taken off quickly and easily so that the advantages of the open construction would not need to be lost permanently because they were used. At the same time the range of mounted equipment might be expected to grow, taking advantage of the greater choice both of space and of speed. It is possible that particular advantage might be taken of the ability of the tractor to operate at very slow speeds where a steplessly variable speed range is especially valuable if maximum output is to be obtained.

A long-standing problem that might well be influenced by the introduction of the hydrostatic transmission is that of the use of four-wheel-drive tractors in agriculture. In spite of their obvious suitability for a number of purposes, these machines have never appeared in large numbers, presumably because of the difficulty of making a mechanically sound machine at a reasonable price. It would appear to be fairly easy to overcome this difficulty if a basic two-wheel drive hydrostatic tractor in quantity production was designed to be convertible to four-wheel-drive by the substitution of a different front axle and front wheels incorporating wheel motors. It should be noted that it would not be difficult to prevent undesired differential rotation between any of the wheels by introducing a simple form of flow divider. Equally, of course, it is a simple matter to provide an effective " differential lock " on the two-wheel-drive tractor, or to make arrangements for power-assisted steering.

In the field of large earth-moving tractors, both wheeled and tracked, the hydrostatic transmission offers a means of solving another long-standing problem : how to ensure that the tractor always has instantly available the maximum " lugging " power of which the tracks are capable in the prevailing conditions. Various means have been used of increasing the torque back-up of engines used in earth-moving tractors so as to increase the available tractive effort throughout the range of gears, although the actual horsepower developed by the engine was adequate in the first place. With a hydrostatic transmission it would be a simple matter to devise an automatic control that would adjust the speed continuously so that the rate of working was varied according to the operating conditions to keep the engine working steadily at a predetermined horsepower, say, 85 per cent of maximum. With such a control, overruled by the operator, if necessary, to prevent excessively high speeds, a very high rate of working could be achieved.

In this instance, the hydrostatic transmission might alter the pattern of development work on power units and it may well be that, in general, it is in this direction that the biggest impact will be made. When a hydrostatic transmission is used the problem of the engine designer is simplified : the requirement is simply a given maximum power with minimum fuel consumption ; the torque characteristic is of no importance and the engine need not run at variable speeds if there would be any advantage in not doing so. The simple form of gas turbine could be used with a hydrostatic transmission. This is interesting because, in spite of its high fuel consumption at the present time, this power unit looks very attractive, particularly from the point of view of maintenance. An extremely attractive proposition, in theory, is a gas turbine driving a high-speed ball piston pump running at about 40,000 r.p.m., supplying oil to hydrostatic motors ; but it must be admitted that this is somewhat visionary.

Without straining the vision too much, however, it is evident that the hydrostatic transmission, by making it practicable to use gas turbines in tractors, might radically alter present conceptions of the relation between power and physical size. The modern medium-sized tractor is about as large, in physical dimensions, as can be considered convenient for general use, but it is by no means as certain that it is as powerful as could be desired, if extra power could be packed into the existing space. With the gas turbine and a hydrostatic transmission this could be done and the question then arises of exactly how much power could usefully be absorbed in ordinary farming operations, and whether it is possible to determine a theoretical optimum value. This is possibly the most interesting speculation of all.

Welding Technical Service Department

An important section of the organisation of British Oxygen Gases, Ltd., is the sales technical services department, which was first set up in 1935 to give technical assistance to all branches of industry using welding processes. The advances made in welding techniques and the development of new processes have resulted in a steady growth of this department, and it recently became necessary to lay down new premises to provide it with sufficient up-to-date accommodation. These new premises were recently opened at the Cricklewood works of the company by Sir Frederick Handley Page.

The new premises are arranged in two blocks, one including offices, a lecture theatre and a photographic department ; and the other a welding school, demonstration shops, and a process development shop. The activities of the department are arranged in two sections—general service and process development. The general service section is concerned with all the company's standard processes and equipment, and is staffed by specialists who give practical advice and demonstrate the processes and equipment both at the centre and in customers' works.

An important part of the work of the general service section is the school for welders in which nearly a thousand operators are trained each year in oxy-acetylene welding and cutting and " Argonarc " welding. This welding school occupies a large area in one of the two new buildings, and adjoining it is a demonstration shop containing representative installations of the range of cutting and welding equipment made by the firm and its associate companies.

In an adjoining shop used for demonstrating cutting processes equipment is installed for powder cutting of stainless and other high chromium steels ; an equipment for top heating ingots to reduce cavitation and porosity due to the rapid cooling of the upper part of a cast ; and an M.C. 50 blowpipe on a rig for cutting large sections of metal up to 50in thick. One of the shops in this building is devoted to process development work and liaison with customers for special plant. One of the special machines recently developed is an automatic arc length control " Argonarc " welder which follows the contours of a workpiece of irregular profile. Another " Argonarc " equipment is being used in experiments in welding metals such as titanium and zirconium, and the development of suitable welding techniques.

Electromagnetic Pumps for Liquid Metals

WE have received some details of electromagnetic pumps which are being developed by the British Thomson-Houston Company, Ltd., for handling liquid metals in nuclear power plants. Sodium, sodium-potassium and lithium are among the metals likely to be used as coolants in nuclear power applications, where high rates of heat transfer are required at high temperatures. Bismuth, too, may be useful, particularly in liquid fuel reactors, because it has low neutron absorption cross section and can dissolve uranium.

There are two main kinds of electromagnetic pumps—conduction, either a.c. or d.c., and induction—and the choice depends mainly on the pumping requirements and on the physical

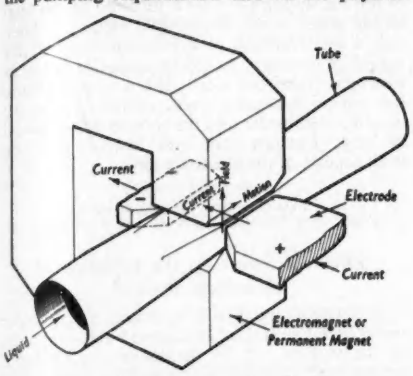


Fig.1—Principles of d.c. conduction pump

properties of the liquid metal. For bismuth, with its high density, viscosity and resistivity, the d.c. conduction pump is generally preferable. The elements of the pump are shown diagrammatically in Fig. 1 and the principle of operation, like that of the electric motor is that, if a magnetic field is maintained at right angles to a current-carrying conductor, a force is exerted at right angles to the current and the field. The direction of the force is determined by Fleming's "Left-hand rule," as symbolised by arrows in Fig. 1. In the case of the d.c. conduction pump the current is produced from an external source and is transmitted, via two electrodes, through the liquid in the direction shown. The field, at right angles to the current, is produced by a permanent magnet or electromagnet and the resulting force causes the liquid to move along the tube from left to right (Fig. 1).

A major disadvantage of d.c. conduction pumps is that it is difficult in practice to meet the requirements of large electrode currents at very low voltages. For example, a 100 h.p. pump of recent design required 100,000A at 2·5V. An efficiency of about 40 per cent is attainable with a pump of this size.

Alternating current excitation of the conduction pump simplifies the task of supplying the electrode current, but at large outputs the efficiency is lower than with direct current. However, acceptable power factors and efficiencies can be achieved with smaller a.c. conduction pumps and liquids of both groups, sodium and bismuth, can be handled. A typical a.c. conduction pump designed to pump bismuth at 15 gallons per minute, 15 lb per square inch and 450 deg. Cent., is shown in Fig. 3.

The second main method of electromagnetic pumping is by inducing current in the liquid metal and an obvious way of doing this, particularly with metals like sodium, is to use the induction motor principle. One adaptation of this principle is in the spiral induction pump, which, as outlined in Fig. 4, is, virtually, a standard polyphase stator, with a fixed core instead of a rotor, and a large air gap through which are wound several turns of a rectangular pipe containing the liquid metal that is to be pumped. End rings are necessary, in principle, to establish the desired axial electric current. Because the field is radial the flow of liquid is circumferential and the channel walls or guide vanes constrain the liquid to move spirally along the pump. Spiral induction pumps are specially suited to low-flow high-pressure applications. Pumps

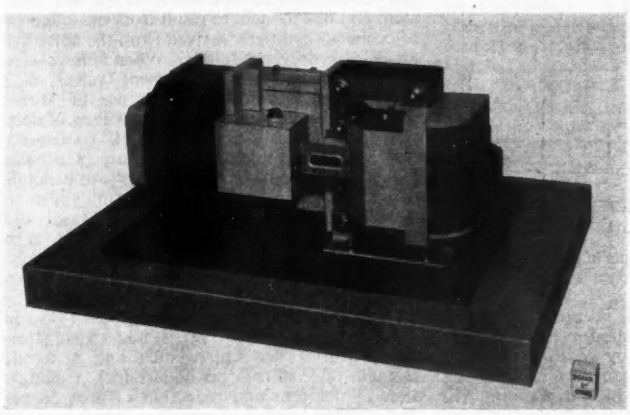


Fig. 3—A.C. conduction pump for handling bismuth, 15 gallons per minute at 15lb per square inch and 450 deg. Cent.

have been designed to deliver 10 gallons per minute at 100 lb per square inch and 40 gallons per minute at 80 lb per square inch, and it is for duties such as these, in ratings up to about 10 h.p., that their main uses have been found.

Another application of the induction principle is in the linear induction pump. It differs from the spiral induction pump in that the liquid channel is straight, that it produces an axial travelling-wave magnetic field and that the current and liquid flow are also axial. There are two main forms of linear induction pump. The first, known as "FLIP," is flat, with a channel of rectangular cross section, with side bars on both narrow sides performing the same function as end rings on an induction motor. Its winding is "developed" flat, the coils being disposed on

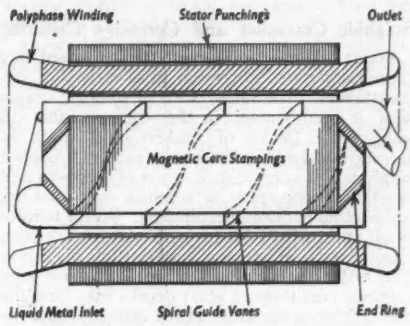


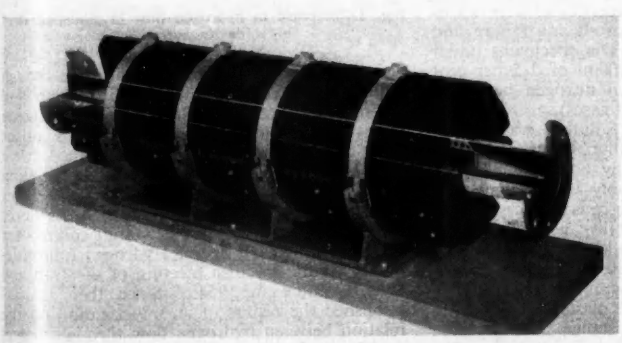
Fig. 4—Spiral induction pump for liquid metals

both the longer sides of the channel. The second form of linear induction pump, "ALIP," has an annular channel enclosing a laminated central core. The outer wall of the annular channel is enclosed by a polyphase winding made up of pancake coils in radially laminated slotted stampings. The pump illustrated in Fig. 2 is designed for an output of 420 gallons per minute of sodium-potassium eutectic alloy at 14 lb per square inch, 175 deg. Cent., with an efficiency of 35 per cent and a power factor of 0·2. With liquid sodium at the same temperature the efficiency is given as 42 per cent. The pump shown should be regarded as a small one of its kind. As the size is increased the efficiency and power factor values improve markedly. In larger sizes it becomes possible to split the winding to allow it to be removed without disturbing the tube.

An alternative arrangement is the coaxial flow ("CALIP") pump, in which the liquid flows along a pipe inside the core and returns in the annular gap between the core and the windings. This arrangement permits of easy removal of the windings as a whole.

The main kinds of electromagnetic pump being made or designed by the British Thomson-Houston Company, Ltd., are listed below.

Pump	Metal	Flow, gals/min	Pressure, lb/sq in	Working temp., deg. Cent.
A.C. conduction ...	Bi	15	15	450
A.C. conduction ...	Hg	6	15	110
D.C. conduction ...	Bi	0·6	50	500
D.C. conduction ...	Bi	5–10	50	500
D.C. conduction ...	Bi	2000	50	500
"CALIP"	Na	400	50	500
"SIP"	Na	30	50	300



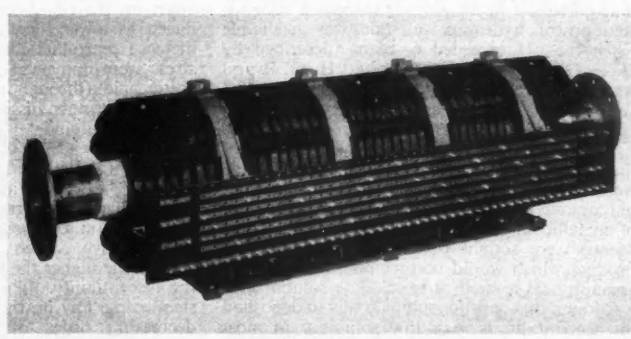


Fig. 2—(Left) cut-away model of annular linear induction pump "ALIP." The tube is surrounded by a large number of "pancake" coils in a magnetic core consisting of twelve radial packets of laminations, producing an axial travelling field which induces the liquid metal to flow along the annulus. (Right)—Annular linear induction pump with covers removed to show laminated radial core, "pancake" coils and terminal board

Metallurgical Topics

Sulphide Corrosion and Corrosion Cracking

SMALL quantities of sulphuretted hydrogen may cause accelerated corrosion in a variety of circumstances. The importance of sulphide corrosion is well known in the coal-gas and oil industries. Decks of tankers and roofs of storage tanks may suffer from attack by hydrogen sulphide. It is present in crude oil deposits and outstanding examples of sulphide corrosion are to be found in oil-well equipment. At the bottom of oil wells, where there is no oxygen or oxidising agent, corrosion occurs in acid-resisting materials. The order of usefulness of metals in resisting sulphide corrosion at great depths may be quite different from the order at the surface where the hydrogen sulphide comes in contact with air and conditions become more acid.

In the November issue of the journal *Corrosion*, space is devoted to three papers on sulphide corrosion.[1] Two of them are concerned with the use of ammonia gas as a preventive. Some years ago it was suggested that the injection of anhydrous ammonia into the vapour space of tanks holding sour crude oil would reduce the

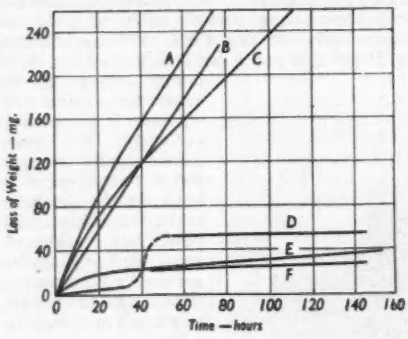


Fig. 1—Corrosion measurements in N-sodium chloride solution saturated with hydrogen sulphide (Ewing)

corrosion of the tank steel. Results of tests of the effectiveness of this method over a four-year period have been reported by W. F. Rogers and cannot be said to have been very encouraging under the conditions to which it was applied. Previously unexposed steel was protected from the onset of corrosion for about four to eight months. To effect this beneficial result on steel initially free from iron sulphide, sufficient ammonia had to be used in the vapour space of sour oil tanks to develop a pH value in the condensed water of 9·5 to 11·5 (i.e. to ensure that the condensed water was alkaline). Meanwhile, a corrosion product of iron sulphide slowly accumulated. When a coating of iron sulphide had formed (or if it was initially present) the use of ammonia did not significantly retard the rate of corrosion. The author of this paper was of the opinion that the use of ammonia in the casing-tubing annular space of sulphide oil wells would have only a similar temporary effect. Nevertheless, in view of the reported successful use of ammonia in the vapour space of tanks, and of the results of laboratory tests which showed that corrosion in an air-free saturated aqueous solution of hydrogen sulphide was negligible when the pH exceeded 6, plans (described by H. E. Greenwell, R. Lancaric and H. G. Byars) were made for ammonia treatment to control vapour space corrosion at considerable depths in the casing of crude oil wells.

In the third paper, electrochemical studies of the mechanism of corrosion by hydrogen sulphide were reported by S. P. Ewing. These brought out, among other things, the protective character of metallic sulphide films in alkaline solutions. Means were sought of producing a corrosion product which would be precipitated on anodic areas in acid as well as in alkaline solution. It was found that cuprous sulphide was so deposited on account of its very low solubility in most acids. If a thin copper coating were plated on steel, the copper would quickly be converted into cuprous sulphide and this material might have some protective properties. Tests were made in N-sodium chloride solution saturated with hydrogen sulphide on specimens (surface area 6 square inches) of Armco iron, mild steel, a copper-bearing mild steel and, for comparison, a sample of commercial copper and two specimens of copper-plated steel. The results are shown in Fig. 1. A higher copper content in the mild steel might have been an advantage, but the diagram clearly shows the pronounced effect of copper plating. Some results indicated that the effectiveness of a copper coating was not impaired when it was formed over a thin layer of ferrous sulphide. The coating might, therefore, be applied to the interior of a pipeline by running a plug of copper sulphate solution behind a pipe-cleaning plug.

It would appear that electrochemical studies like those of S. P. Ewing, taking consideration of the conditions for the particular application intended, are an essential preliminary to the discovery of effective preventive measures to combat sulphide corrosion.

SULPHIDE CORROSION CRACKING

Even more dangerous than progressive sulphide corrosion is the sudden failure by spontaneous cracking of high-strength steel equipment handling sour gas or crude oil. Such failures often occur after relatively short exposure. The effect was at one time classed as hydrogen embrittlement and was thought to result from the influence of occluded hydrogen derived from the corrosive attack of hydrogen sulphide. When failures were only in small items of equipment (valves, &c.) the solution was found in the use of Monel metal. In recent years, however, drilling of deep wells and the discovery of sour gas condensate reservoirs has resulted in the failure of tubular materials by spontaneous cracking. An example of such a failure in a manganese-molybdenum steel has been described by J. P. Fraser and R. S. Treseder.[2] The failure occurred at a depth of 1429ft (at 1ft below a joint) in a tube conveying gas containing 3·5 per cent hydrogen sulphide and 6 per cent carbon dioxide. The steel contained carbon 0·49, manganese 1·45 and molybdenum 0·42 per cent. It had a yield stress of 37·5 tons per square inch and a tensile strength of 55·8 tons per square inch; elongation 23 per cent and reduction of area 56 per cent. The known stresses to which it was subjected were 20·3 tons per square inch tension due to the weight of the tube, 3000 lb per square inch internal gas pressure and 500 lb per square inch external fluid pressure. They were thus far lower than the yield strength of the tube. The temperature at the bottom was 92 deg. Cent. and at the well-head 40 deg. Cent. The failure occurred by sudden transverse parting after exposure of the tubing to the well fluids for only a few weeks. There was no evidence of any manufacturing defects or of mechanical abuse. The authors carried out a series of experiments on small strips of steels of various compositions. The strips ($\frac{1}{16}$in by $\frac{3}{16}$in by 3in) were mounted in a stainless steel holder, the contacts being of glass. They were bent by means of a screw to give prearranged outer fibre stresses. Stress raisers in the form of two drilled holes 0·06in apart on the transverse centre line, were introduced to lower the load-producing failure and increase reproducibility. The specimens under stress were immersed in 200ml of 0·5 per cent acetic acid (through which nitrogen had been passed to remove dissolved gases) saturated with hydrogen sulphide. The solution was resaturated periodically by bubbling hydrogen sulphide through it. Failure usually occurred in a few days. A field test assembly was designed on similar lines. The cracking was transcrystalline. The criterion of susceptibility was the critical stress above which cracking occurred. In general the higher the tensile strength the greater the susceptibility. The high-nickel acid-resisting steels came low on the list of steels arranged in decreasing order of resistance to corrosion cracking under the conditions studied. The normalised manganese-molybdenum steel tempered at 600 deg. Cent. (with consequent decrease in tensile strength) showed increased resistance to fracture and still further improvement was obtained by oil-hardening and tempering. It is of interest to note that the same treatment makes the steel less notch-sensitive.

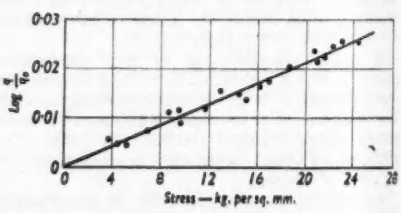
There did not appear to be any correlation between embrittlement and cracking, which argues against the hydrogen embrittlement theory. When a susceptible steel was coated with an organic coating no failures occurred at loads high enough to produce cracking in an uncoated specimen, though such a specimen was almost as embrittled as one without a coating. In the discussion the suggestion was made that failure was due to a combination of stress corrosion cracking and the effect of hydrogen absorbed by the steel. The degree to which each factor influenced the failure, as well as the time of failure, appeared to be a function of the total tensile stress in the susceptible metal. If high, only a small amount of stress corrosion cracking would be necessary to induce complete failure in hydrogen embrittled steel. If low (but still above the critical amount), stress corrosion cracking would predominate and the time to failure would be long. Further work is evidently required on both aspects of the phenomenon.

REFERENCES

[1] *Corrosion*, November, 1955, pages 42, 44 and 51.
[2] *Trans. Amer. Soc. Mech. Engineers*, August, 1955, page 817.

Effect of Stress on the Diffusion of Hydrogen in Steel

IF a wire charged with hydrogen is bent under water or oil, a flush of hydrogen bubbles appears at the surface. P. W. Bridgman found that a hollow steel cylinder containing hydrogen under pressure allowed the hydrogen to escape with explosive violence when the pressure reached 9000 atmospheres. The cylinder was not obviously ruptured; in fact, it was said to have been difficult to see where the escape had taken place. The procedure could be repeated a number of times, a crack of visible size gradually developing with repetition. At this pressure a considerable amount of plastic deformation must have occurred. Zapffe covered the surface of a hydrogen-charged sample of steel with an oil film and observed under the microscope that bubbles of regular size appeared at deformation markings such as slip planes or Neumann bands. Noren and Erikson, working on similar lines, found that hydrogen was first evolved at random sites, indicating lattice diffusion, but a sudden formation of bubbles along certain markings



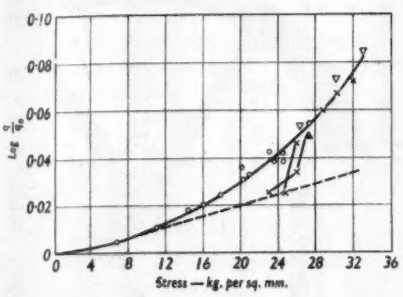
p = the amount of hydrogen which passed through unit length of the cylindrical tube in unit time.
Log q/q_0 at 24kg per square millimetre = 0·025, corresponding to 6 per cent increase in rate of flow.

Fig. 1—Increase in hydrogen flow in annealed steel (de Kazinczy)

was visible for a long time after diffusion though the lattice had practically ceased. These and several other examples, illustrating the diffusion of hydrogen through steel which was under stress or had been plastically deformed, were cited by F. de Kazinczy in his latest contribution to the study of hydrogen embrittlement. This author is a member of the Swedish Institute of Metal Research, Stockholm, and contributed a paper on "A Theory of Hydrogen Embrittlement" at the Swedish meeting of the Iron and Steel Institute in 1954[1]. Since then he has published the results of an investigation on the relation between hydrogen flow through a steel membrane and current density in electrolytic charging, throwing some light on the conditions under which blisters may be formed in pickling.[2]

In several of the previous studies now quoted

by de Kazinczy (including those given above) it was difficult to separate the effects of structural changes caused by plastic deformation, internal stress and applied stress, and he has therefore made a separate study of one of these variables.[3] Measurements were made of the steady state flow of hydrogen through cylindrical steel tubes subjected to tensile stresses. Hydrogen was discharged electrolytically at the external surface of the tube and the gas evolved at the internal surface was collected in an initially evacuated bulb. The flow was calculated from the increase of pressure in the bulb. After a loading which resulted in little or no plastic deformation steady state flow was obtained within a few minutes, and the increase in hydrogen flow was almost proportional to the tensile stress. The elastic limit of the mild steel tubes was about 19·5kg per square millimetre and the 0·2 per cent yield strength was 22·2kg per square millimetre (14·1 tons per square inch). The ratio of the flow in the stressed to that in the unstressed tubes (q/q_0) is shown logarithmically in Figs. 1 and 2. When the stress was raised to 25kg per square millimetre (corresponding to at least 0·6 per



Open circles represent measurements in samples which had been previously deformed at higher stresses; other markings indicate results obtained at a stress at which the sample was subjected to plastic deformation.

Fig. 2—Increase in hydrogen flow in steel subjected to plastic deformation (de Kazinczy)

cent plastic elongation), the flow increased appreciably above the proportional value. After release of the stress the flow returned to approximately its original value (q_0), though there was a tendency to a slight increase. In Fig. 2 values along the curve show the increase in hydrogen flow in relation to applied tensile stress in tubes previously subjected to plastic elongation between 1·5 and 7·2 per cent. At stresses above 11kg per square millimetre all these samples showed an increased effect of stresses on hydrogen flow. The degree of the previous deformation within this range did not affect the results appreciably, but the logarithmic flow ratio is not proportional to the stress as in the annealed tubes.

The measurements indicated that the passage of hydrogen through the elastically deformed annealed steel tubes took place by lattice diffusion in a regular homogeneous manner. In the absence of external stress, plastic deformation within the range investigated had only a slight effect on hydrogen flow. In the stressed state the flow in plastically deformed steel increased considerably more than could be accounted for by homogeneous lattice diffusion, and the time taken to attain a steady state of flow increased when the stressing involved plastic deformation.

[1] *Journal of the Iron and Steel Institute*, May, 1954, Vol. 177 page 85.
[2] *Jernkontorets Annaler*, July, 1955, page 466.
[3] *ibid.*, November, 1955, page 885.

Intercrystalline Corrosion of a Titanium-Stabilised Chromium-Nickel Steel

THE titanium carbide in a chromium-nickel austenitic steel containing titanium is slightly soluble in the austenite at high temperatures, dissociating into titanium and carbon atoms in solid solution. When the steel is reheated at 600 deg. to 850 deg. Cent. the carbon atoms may combine with the adjacent chromium, rather than with the widely dispersed titanium atoms, producing local impoverishment of the matrix in chromium and consequent impairment of corrosion resistance to an extent dependent on the time and temperature of heating for quenching and of reheating. After water quenching from 1050 deg. Cent. decrease in corrosion resistance is not great, with very little susceptibility to intercrystalline corrosion, but higher temperatures of quenching tend to intensify these effects.

After prolonged reheating at about 850 deg. Cent. the harmful effect on corrosion resistance is eliminated, and a treatment which involves reheating at 850 deg. Cent. for periods up to four hours has been used commercially in America as a "stabilising treatment."*

The precipitation process in a titanium-stabilised austenitic chromium-nickel steel in its relation to intercrystalline corrosion has been studied by K. Bungardt and G. Lennartz† in a steel containing carbon 0·07, chromium 17·5, nickel 10·4, molybdenum 0·4 and titanium 0·47 per cent. The influence of quenching temperatures between 1000 deg. and 1300 deg. Cent., and of times at these temperatures, on the course of the precipitation of carbides during subsequent annealing at temperatures between 500 deg. and 800 deg. Cent. for times up to 2000 hours, was studied by means of analytical and radiological methods, and the results were linked up with the degree of intercrystalline corrosion shown in tests with hot copper sulphate–sulphuric acid solution. After the various heat treatments had been applied, the carbides ($Cr_{23}C_6$ and TiC) were isolated by electrolysis in alcoholic hydrochloric acid solution and their relative proportions determined.

The conclusions arrived at were, that after water quenching and subsequent annealing:

(1) At 500 deg. Cent., even after 2000 hours, there was no appreciable precipitation of chromium carbide or titanium carbide, neither was any intercrystalline corrosion observed.

(2) At 600 deg. Cent., the precipitate was mainly chromium carbide. Titanium carbide was precipitated slowly in very small amounts whereas

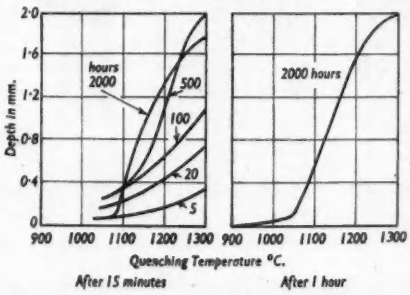


Fig. 1—Depth of attack after annealing at 600 deg. Cent. for different times, and heating for fifty hours in copper sulphate-sulphuric acid solution (Bungardt and Lennartz)

chromium carbide was precipitated more quickly in amounts which increased with time of annealing. The rate of formation of chromium carbide was initially greater in specimens held for fifteen minutes at the quenching temperature than in those held for one hour. Intercrystalline corrosion appeared after five hours annealing in the specimens which had been held at a quenching temperature of 1050 deg. Cent. for fifteen minutes, but in those held for one hour at the quenching temperature it did not occur until the annealing time reached 2000 hours. In the first case, more pronounced local impoverishment of the matrix in chromium would be caused by the more rapid separation of chromium carbide.

(3) At 700 deg. Cent., titanium carbide and chromium carbide were precipitated side by side with a greater rate of formation than at 600 deg. Cent. The first formed chromium carbide was re-dissolved with increasing time of annealing, its carbon content going to form more titanium carbide and its chromium content enriching the matrix in chromium with consequent formation locally of the sigma constituent (FeCr). This stage was reached after 100 hours annealing. The chromium content of the precipitated carbides was somewhat less than after annealing at 600 deg. Cent. Diffusion would occur more rapidly at 700 deg. Cent. than at 600 deg. Cent., thus flattening out the chromium gradient at the impoverished regions. No susceptibility to intercrystalline cracking was observed.

(4) At 800 deg. Cent., precipitation took place as at 700 deg. Cent., but the formation of titanium carbide occurred at a greater rate with consequent restraint on the separation of chromium carbide. No intercrystalline attack was produced by the acid copper sulphate solution.

Intercrystalline corrosion was shown only in specimens annealed at 600 deg. Cent., and the extent of the damage in tests made in hot acid copper sulphate solution is indicated in Fig. 1. High quenching temperatures resulted in increased depths of attack because chromium carbide precipitation in these materials was greater in relation to grain size, though not in total amount. In the material water quenched from 1050 deg. Cent., after fifteen minutes at that temperature maximum damage occurred after annealing at about 500 hours at 600 deg. Cent.

* F. H. Keating, *Chromium-Nickel Austenitic Steels* (Butterworth's Scientific Publications), 1956, pages 17–18.
† *Archiv für das Eisenhüttenwesen*, February 1956, page 127.

Notched-Bar Tests on Carbon Steels

A SOMEWHAT elaborate statistical study of the scatter and degree of discrimination shown by various forms of test for brittleness in steel has been carried out by H. Knüppel and K. E. Mayer.* The types of test studied included the Schnadt impact test on several forms of specimen, the DVM test on specimens with different diameters of notch and at different temperatures, the notch-impact and notch-tensile tests of W. Kuntze, and the notch-bend test of N. A. Kahn and E. A. Imbembo (the U.S. Navy tear test). The tests were made on 102 carbon steels, of which 95 were unkilled (82 basic Bessemer and 13 open-hearth) and 7 were killed (3 basic Bessemer and 4 open-hearth). The object was to determine which kind of test was most suitable for accurate discrimination of the steels one from another, with minimum scatter of the individual results. Most of the work was carried out on the unkilled steels.

The "standard deviation" shown by each form of test piece was determined for the basic Bessemer and open-hearth steels separately and designated s_A and s_B respectively. One criterion of the discriminatory value of the test was taken to be T equal to the root mean square of s_A and s_B divided by the scatter of the results of all ninety-five steels.

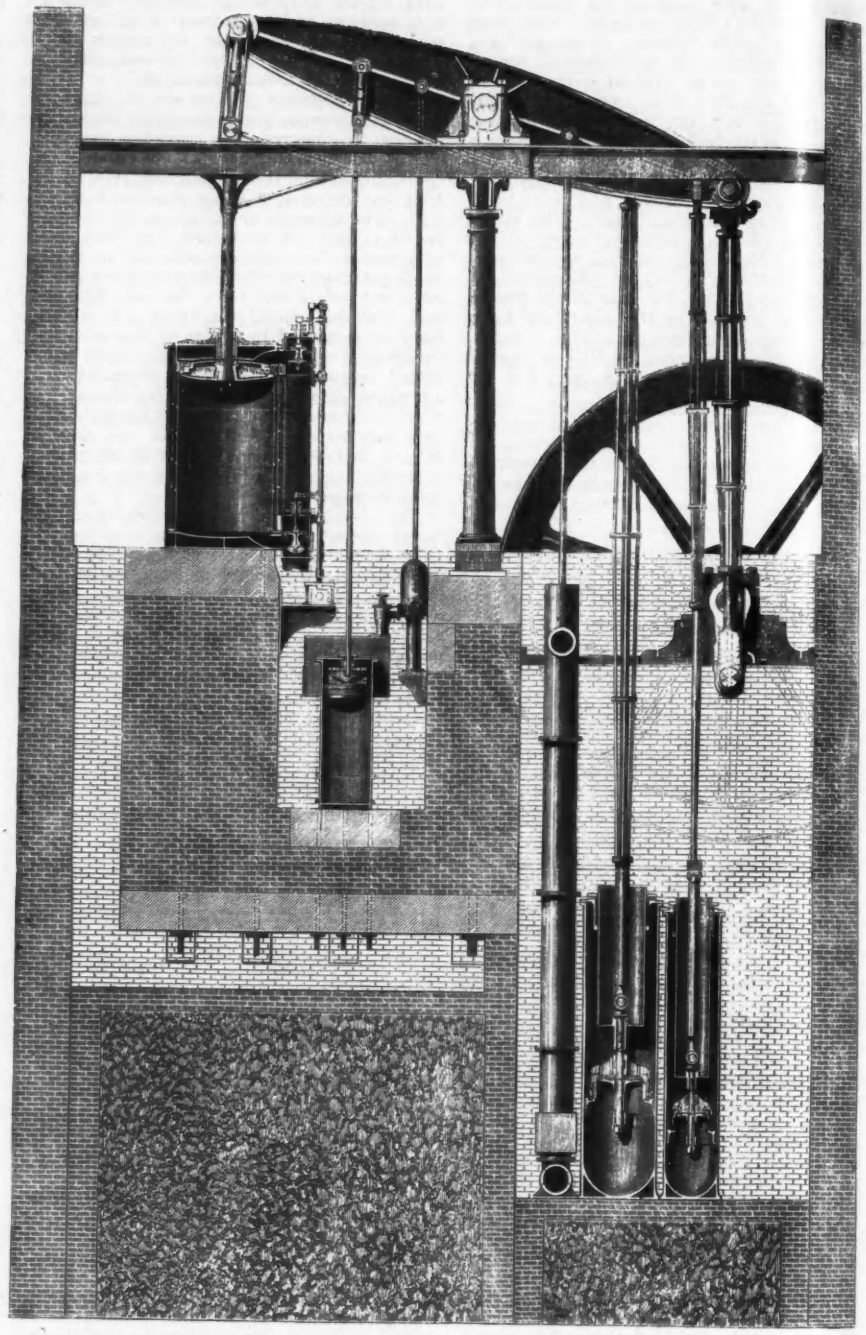
An attempt was made to determine the effect of composition on the test results on different steels, and coefficients were deduced for all the chemical constituents, including nitrogen and oxygen. From a linear equation containing these coefficients another criterion B was calculated, representing the percentage of the variations which was due to differences in chemical composition: $(100-B)$ was therefore the maximum proportion of scatter due to the test. From the study of the effect of chemical composition it was concluded that the tough-to-brittle transition temperature was raised by phosphorus and nitrogen, and lowered by manganese and oxygen; i.e. with increased oxygen the steel appeared to be improved, though this effect might be due to strings of oxide intercepting the crack formed at the root of the notch.

The transition temperature varies not only with composition but also with different forms of test piece, and so far as scatter is concerned this laborious piece of work appears only to show that the least satisfactory form of test is that in which conditions coincide with the region of transition. Out of forty-three sets of conditions of test twenty-two are ruled out as unsuitable, but no definite recommendations are made as to the order of preference of the others. It is, however, implied that the DVM test piece with the 2mm diameter notch is satisfactory, though for steels which give a high value of energy absorbed a sharper notch may be used. One definite conclusion drawn from the results is that the best and most certain way to distinguish between the different qualities of steels of the type investigated is to make tests on the material in the strain-aged condition, i.e. as cold-worked 10 per cent and heated for half an hour at 250 deg. Cent. Results on the strain-aged material, given by the DVM test piece with 2mm diameter notch at 50 deg. Cent. were much more consistent and informative than tests on the unaged steel at room temperature or at −20 deg. Cent.

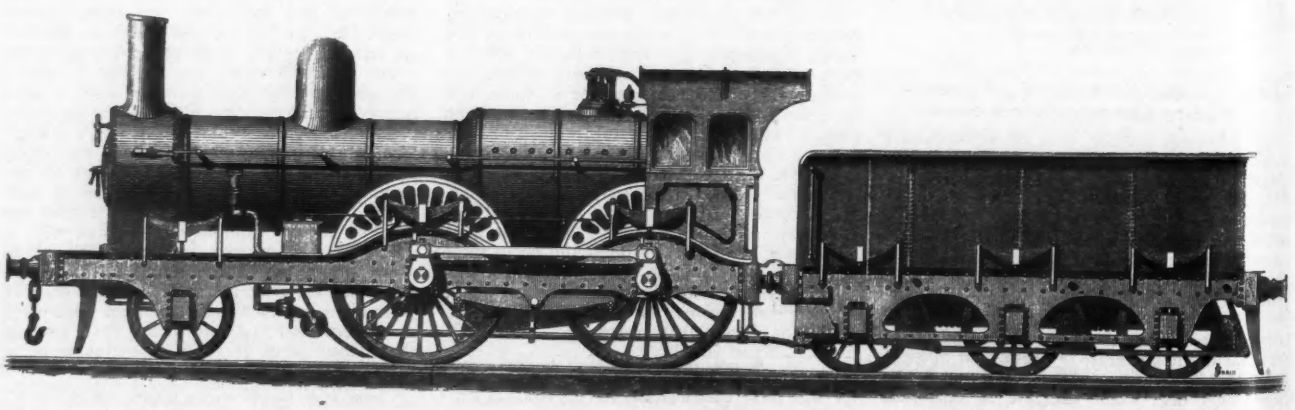
* *Archiv für das Eisenhüttenwesen*, January, 1956, page 25.

Engravings of 1866

The upper engraving on this page, which is reproduced from our issue of October 26, 1866, shows a 200 h.p. pumping engine constructed for the New River Waterworks by James Watt and Co., at Soho, Birmingham. Two of these engines, named the "Lion" and "Lioness," were supplied by Watt. On the ground that "very little has been published respecting them," we printed a detailed description, commenting on the "very excellent duty realised with them." This description records that "each engine is provided with two pumps, both of the plunger and bucket variety, placed with their centres in a line with the longitudinal centre line of the beam, inside the crankshaft. The outer pump has its centre as near to the shaft as will admit of the free vibration of the connecting rod. It is worked from the beam by means of two wrought iron connecting rods, one descending from either side, and attached to the plunger of the pump by a crosshead, and the crank is made to revolve between them." Our description goes on to set out the principal dimensions of the engines, as follows: "the diameter of the cylinder is 60in and the length of stroke is 8ft; the steam ports are each 7in wide by 24in long. The steam valves are each 11in in diameter. . . . . From the centre of the beam to the centre of the pin of the connecting rods the distance is 13ft 6in, and to that of the first and second pumps 8ft and 11ft 9¾in, respectively, and to the centre of the air pumps the distance is 6ft 9in." It is also explained that "the large pump is provided with a bucket 43½in in diameter and a plunger 30½in in diameter, having a stroke of 4ft 9in and delivering 308 gallons per stroke. The small one has a bucket 31½in in diameter, and a plunger 22in in diameter, with a stroke of 7ft, delivering 230 gallons per stroke." The steam power for the two engines was provided by eight single-tubed Cornish boilers with side and bottom flues. The boilers were each 32ft long and 5ft 10in in diameter, and each a steam dome 3ft in diameter and 5ft high.



Below there is reproduced from our issue of December 21, 1866, an engraving of an express passenger locomotive, which was designed by Mr. T. W. Rumble, "for extraordinarily heavy service on one of our great English lines." We suggested that the design, while presenting no novel features, exerted "a powerful claim on the attention of engineers." The engine was still in the design stage at the time our description was published, but we, nevertheless, remarked that "the express passenger service on this line will be conducted at a great speed and with very heavy trains, and the locomotives working this traffic will, therefore, be of the very largest class admissible on the narrow gauge, and they have been designed to develop maximum power." The engines, our article continues, "will have inside cylinders and six wheels, four of which will be coupled. The cylinders will be 18in in diameter and 24in stroke, the driving wheels being 7ft in diameter. These dimensions at once place the engines in the ranks of the largest locomotives ever built in England; but it is well to remark that their weight is not greater than that of many now running on the Great Western and the London and North Western Railways—a result mainly due to the extended use of steel throughout."



LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

HOUSEHOLDS AND EARNERS

SIR,—I was particularly interested in the article "Households and Earners" (THE ENGINEER, March 2, 1956). I feel, however, that the article gave a misleading impression in the case of the bachelor, i.e. the young man as yet unmarried.

Few young men set out with the deliberate intention of remaining bachelors, and, therefore, whilst admitting that they could, if they so wished, enjoy a higher standard of living than a married man with the same income, the need to provide for an eventual marriage prevents them from doing so. Thus, to suggest in your article that a bachelor does not need the same income as a married man is, in my opinion, illogical, since the bachelor has to provide a home before he can hope to marry. The failure of the Government to realise this is beginning to have serious repercussions which will worsen with time if nothing is done to relieve the burden at present being imposed upon young people.

A few years ago, most young people would reckon to be married by the mid-twenties. Yet to-day, when I examine the group containing my friends, I find that there are still quite a few unmarried even in their late twenties, and all because of the simple fact that they cannot afford to marry.

Why is it that a young man in the late twenties claims that he cannot afford to marry? Here I quote my own case, though I do not necessarily claim that it is typical of most of the young people in my group. I am twenty-seven years of age and still unmarried. In the eleven years since I started earning a living I have struggled to save £600—and I mean struggled. I do not smoke cigarettes, I have not had the pleasure of owning a car or motor-cycle, and I can safely claim not to have been extravagant in my spending. Yet it has taken me eleven years to save £600, because of the poor wage paid to apprentices and learners, and the fact that I spent three years at a university (most other young men have to do two years' National Service). Five years ago, I would have considered £600 sufficient for marriage, but the rapidly rising cost-of-living makes it not nearly enough to-day.

Before I can provide a home, I need a house—a moderately priced house nowadays costs about £2500. To furnish it with the bare essentials and to meet the incidental expenses of a marriage will cost at least another £500. Therefore, I shall need to obtain about £3000 to provide the basis for a marriage. Assuming I am prepared to take out a mortgage policy for £2000, it still means I have to save £1000.

Out of my present salary (approaching four figures) I lose over £200 in deductions for income tax, pension fund, &c. From what is left I estimate I can save approximately £300 per year, and at this rate I shall be nearly twenty-nine years of age before I achieve my £1000, and the question is will £1000 be enough in 1958? It is, indeed, disheartening to try to save and see your savings devaluate as rapidly as they are doing now.

If I do marry in 1958 and my wife is of the same age as myself, it will mean that we have lost nearly 50 per cent of our child-bearing life, as reckoned from the age of 21. In addition, once we are married we will still have a £2000 mortgage to pay off, which, if taken over twenty years together with insurances, will work out at approximately £200 per year. Because of the uncertainty of the future, I, like most people, would hate to have this millstone round my neck for twenty years. So my one aim will be to pay off the mortgage as quickly as I can before I undertake any other burdens. If it takes ten years to pay off the mortgage it means that we are virtually too old to have a family and so we become one of the no-family or small family groups, whereas I would quite willingly support a family with three or four children if the circumstances permitted it.

These are the serious repercussions which must be faced if the Government continues in its policy to make young people trying to set up home the biggest sufferers; by making the young man one of the most heavily taxed, in imposing high purchase tax on essential household items, and creating the inflationary and unstable economic conditions existing in the country to-day.

Though what I have written may be said to be outside the realm of engineering, it is a factor which has to be taken into account by the young engineer in deciding his future career. Nowadays we hear so much about the shortage of technicians which I consider has arisen partly as a result of the poor salary offered to young technicians compared with the wages offered by the manual trades, and since the early years of a young engineer's career is the time when financial need is greatest, in my opinion many promising engineers have been forced into the manual trades, who might otherwise have entered the technical branches of engineering.

To emphasise my point, take two fictitious men, one is earning £600 per annum from the age of twenty-one, whilst the other is on an increasing scale from £450 at twenty-one years, rising by £50 per year. The men will be twenty-eight years of age before the man on a rising scale gains any benefit over the man on a fixed scale. Most manual workers can earn well above £600 per year whilst it is considered quite good for a technician to be on a salary above £800 at about twenty-eight years of age. Is it any wonder, then, why we are so short of men in the technical branches of industry?

K. N. MATTHEWS

Smethwick, 40, Staffs,
April 10th.

VACUUM BRAKES ON FREIGHT TRAINS

SIR,—I would like to endorse your comments in the editorial of the issue of THE ENGINEER dated March 23, 1956, referring to the decision of the British Transport Commission to adopt the automatic vacuum brake on freight trains. There is another argument in favour of the air brake, in that all the Continental railway systems use it. I believe that there is now a fair traffic over the cross-Channel wagon ferries, which would have to be worked "loose" on the lines of British Railways, as they are to-day in the main. As it is at present, a lot of traffic has to be handled at each side of the Channel, thereby slowing transit times. A secondary advantage in favour of the air brake is that British Railways could participate in the wagon pool operated by many of the Continental systems to cut the waste, due to empty wagon mileage, to a minimum. Would it be too much to hope that a reversal of the Commission's decided policy would lead to such an increase of railborne traffic that the Channel tunnel schemes could be brought out for further discussions?

J. L. LEAN

Ealing, April 20th.

Literature

Introduction à la Mecanique des Milieux Continus. By PAUL ANGLES D'AURIAC. Publications Scientifiques et Techniques du Ministère de L'Air, No. 306. Service de Documentation et D'Information Technique de L'Aeronautique (SDIT), Magasin C.T.O., 2, Avenue de la Porte D'Issy, Paris (15e). Price 1300 francs.

THE first part of this study contains a purely geometric and generally valid treatment of the kinematics of continuous media. This theory does not depend on the particular physical cause which effects the deformations. After a chapter dealing with applications of the foregoing, the author gives a general theory of constraints which again applies to all cases, whatever might be the physical laws governing the situation. For the different physical states the resulting expressions are established, one chapter dealing in particular with liquids and with fluids generally. Most of the space is devoted to the solid state. A treatment of the most general case is followed by a study of the mono-axial and bi-axial solid, and the solid of revolution.

Wege zur Wirtschaftlichen Fertigung im Arbeitsmaschinenbau. By P. LANGE and W. ROSSBERG. Verlag W. Girardet, Gerswidastrasse 2, Essen: Price DM. 28·80.

THIS work deals with the manifold aspects involved in the construction of production machines. Beginning with the drawing-board stage, the author discusses the work of the designer, the question of readiness of the design for production, and the building schedule. After dealing with the question of standardisation, the author illustrates his remarks by means of examples with reference to the layout and assembly of machines, the detail design of components and the elimination of fitting operations and remachining. The final chapters deal with ease of operation and of carrying out repairs, and the development of production machines.

Books Received

A.B.C. Abridged Building Classification. British Standards Institution, 2, Park Street, London, W.1. Price 23s. 6d.

Principles of Nuclear Reactor Engineering. By Samuel Glasstone. Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2. Price 60s.

The Geneva Motor Show

No. I

THE 24th Exposition de l'Automobile in Geneva which took place from March 8th to 18th attracted not only the usual large crowd of Swiss motorists, dealers and buyers, but also a considerably greater number of foreign visitors than ever before. Not less than eighty-three different makes of motor-cars and seventy-five of commercial vehicles were shown by manufacturers from all the motor-producing countries of the world, thus giving the opportunity of comparing at first hand the relative merits of the various nations' automobile design, their price, appearance and—last not least—their sales appeal to the Swiss customer.

One may wonder why the reaction of the Swiss customer should be of such great interest, and why the Swiss market is considered important enough by practically all the leading motor manufacturers of the world to make representation at the Geneva Salon an absolute "must." Switzerland, having a population of about 4,750,000 people and covering an area about half that of Scotland, is not only a wealthy but also a highly motorised country; the present car circulation amounts to about 280,000, i.e. one car to eighteen people. The average of car ownership is considerably higher in cities than in the country, namely 10 : 1, and the record is held by Geneva where one car is registered per seven heads of the population. Switzerland, having no motor industry of her own—apart from two firms making heavy commercial and public service vehicles—is one of the great importers of motor vehicles, and her imports have risen from 32,500 vehicles (value £165 million) in 1952 to 57,836 (value £230 million) in 1955.

Table I shows the number of motor-cars imported into Switzerland from various American and European countries during the past two years, and Table II the number of commercial and public service vehicles registered in Switzerland in the same period. The tables show that Germany heads the list of Swiss imports, followed by France, Great Britain and Italy, the number of vehicles imported and their relative share of the total imports being almost proportional to the general expansion of the market.

TABLE I—*Swiss Motor-car Imports in* 1954 *and* 1955

	From	1955	Per cent	1954	Per cent
1	Germany	27,729	54·0	22,833	54·5
2	France	6,292	12·3	4,653	11·2
3	Great Britain	5,861	11·4	4,572	11·0
4	Italy	5,781	11·3	4,271	10·4
5	U.S.A.	5,430	10·6	5,271	12·6
	Others	129	0·3	111	0·2
		51,222	100·0	41,717	100·0

TABLE II—*Commercial and Public Service Vehicles Registered in Switzerland in* 1954 *and* 1955

Nationality	1955	Per cent	1954	Per cent
German	2,686	55·3	2,418	53·4
Swiss	683	14·2	650	14·5
French	474	9·8	553	12·2
British	471	9·7	422	9·3
American	236	4·9	298	6·5
Italian	204	4·4	162	3·5
Others	75	1·5	33	0·6
	4,829	100·0	4,536	100·0

The importance of Switzerland as a motor importing country alone would not be sufficient to explain the enormous efforts made by all motor producing countries to promote sales in this highly competitive market. One of the main reasons is that sales effected in Switzerland give a fairly good indication to manufacturers and distributors whether or not any particular make or type of car is likely to appeal to customers in other world markets. Switzerland is a free market, unaffected by protective import duties, restrictions and national bias, a country where the customer is in the fortunate position of being able to buy—within the limits of his means—any car which he fancies or which suits his particular purpose. Contrary to other national motor shows where many foreign manufacturers are showing their products mainly for prestige's sake, all cars exhibited at the Geneva Salon are actually for sale, and every exhibitor is indeed a salesman, expecting to do business, at this great European trade fair. Further, it is generally admitted that a car, acceptable to Swiss customers by reason of its price, appearance and performance, is, or ought to be, also acceptable to customers in other free world markets. The country has long stretches of first-class roads, suitable for high speed, requiring cars of low drag and high lateral stability for safety and comfort. On the other hand the mountainous character of the country, with its numerous passes ascending to heights of more than 8000ft, calls for vehicles of sufficient climbing abilities which have to stand up to considerable differences in temperature and air density. Indeed, the requirements, for cars to perform satisfactorily in these operational conditions, are severe enough to make Swiss roads an excellent proving ground for all sorts of vehicles, and there are few motor manufacturers to-day who are not making use of this opportunity.

There is still another aspect which makes the Geneva Salon particularly interesting to all motor manufacturers, namely the reaction of the Swiss public towards any newly introduced model in respect of eye appeal. Switzerland, though mainly a German-speaking country, has a 30 per cent population of French and Italian origin, i.e. of people who, in matters of taste and fashion, tend to accept the standards of their neighbours beyond the frontiers. Although it might be argued that a motor-car is hardly an object to express national fashion trends, the fact remains that models which satisfy the German as well as the Roman ideal of functional beauty have the greatest sales appeal in Switzerland and, incidentally, also in other free European markets. As appearance is more and more becoming an important selling point in the motor trade, the reaction of the Swiss public to a new model is generally considered a valuable pointer toward its probable effect on other markets.

Although the popularity of any particular make or type of car might not necessarily reflect upon its general quality and its specific suitability in other markets, it gives a fairly good indication what standards of design and body styling seem to be desirable to a wide cross-section of customers on the Continent and in overseas countries with similar economic and geographical conditions.

Table III shows a number of motor-cars of different makes and countries of origin, and Table IV British cars, registered in Switzerland in 1954 and 1955, and their proportional part in the total number of new registrations. It shows that out of about eighty makes, represented in Switzerland, only seventeen or eighteen were able to sell more than 500 cars per year, a clear proof that, desirable as exports to Switzerland may appear to most motor manufacturers, only firms with very efficient sales and service organisation are likely to be successful. The table also shows that very few changes in regard to the popularity of the various makes have occurred between 1954 and 1955, the number of newly registered cars and their relative share of the total registrations being almost proportional to the general expansion of the Swiss market.

TABLE IV—*British Cars Registered in Switzerland in* 1954 *and* 1955

	Make	1955	Per cent	1954	Per cent
1	Ford	2,543	42·0	1,333	28·8
2	Vauxhall	1,001	17·0	1,042	22·9
3	Austin	755	13·0	649	13·8
4	Morris	418	7·0	323	7·0
5	Land-Rover	331	5·6	295	6·3
6	Hillman	318	5·4	276	6·1
7	M.G.	207	3·5	158	3·3
		5,483	93·5	4,029	88·2
	16 other makes	378	6·5	543	11·8
		5,861	100·0	4,572	100·0

We have already mentioned that the popularity of a motor-car in Switzerland is frequently regarded as a criterion, indicating the proficiency of a vehicle, not necessarily in terms of absolute merits, but in functional value, relative to its price, as it appears to the unbiased customer. In lieu of any other recognised standard of relative quality, this assumption has much to recommend it; a close analysis of Table III should be useful, as it allows certain conclusions to be drawn as to why the various schools of national automobile design, represented at the show, seem to have a different sales appeal.

TABLE III—*Motor-cars Registered in Switzerland in* 1954 *and* 1955

	1955 Origin	1955 Make	1955	Per cent		1954 Origin	1954 Make	1954	Per cent
1	German	V.W.	10,077	20·8	1	German	V.W.	8,972	21·6
2	German	Opel	8,408	16·4	2	German	Opel	7,246	17·0
3	Italian	Fiat	5,232	10·2	3	Italian	Fiat	3,906	11·7
4	German	Ford	2,716	5·3	4	German	Ford	2,316	5·1
5	British	Ford	2,453	4·8	5	German	Mercedes	1,741	4·2
6	German	Mercedes	2,452	4·8	6	French	Renault	1,378	3·3
7	French	Renault	1,625	3·2	7	American	Chevrolet	1,335	3·2
8	French	Peugeot	1,457	2·8	8	British	Ford	1,333	3·2
9	American	Chevrolet	1,318	2·6	9	French	Peugeot	1,300	3·1
10	French	Simca	1,280	2·5	10	American	Plymouth	1,242	3·0
11	German	D.K.W.	1,213	2·4	11	German	D.K.W.	1,080	2·6
12	American	Plymouth	1,113	2·2	12	British	Vauxhall	1,042	2·5
13	French	Citroen	1,079	2·0	13	French	Simca	933	2·2
14	German	Borgward	1,073	2·0	14	French	Citroen	881	2·1
15	British	Vauxhall	1,001	1·9	15	British	Austin	649	1·5
16	American	Ford	873	1·7	16	American	Ford	627	1·5
17	British	Austin	755	1·5	17	American	Studebaker	511	1·2
18	French	Ford	619	1·2					
	61 other makes		6,478	12·6		59 other makes		5,225	12·5
			51,222	100·0				41,717	100·0

Turning now to an examination of the exhibited models, we must, for lack of space, exclude from this general survey all commercial vehicles which, built as entirely functional means of transport, are not likely to express to any great extent the national character of their designers or the fashion trends of their country of origin. Like most of the recent International motor shows, the Geneva Salon did not display any marked change from previous styles, nor any remarkably novel innovations. Appearance, however, has become important, for many users are awake to coachwork changes, while improvements concerning technical details are often taken for granted. With the exception of the Renault "Dauphine" and the Fiat "Multipla," the majority of new models have already made their début at last year's autumn motor shows at Frankfurt, Paris and London. Nevertheless, the Geneva Salon was of particular interest to those British observers who, for the purpose of assessing this country's competitive strength, were watching the public reaction to those cars which were making their first appearance in Switzerland. Among these were the 2·4-litre "Jaguar," the new Sunbeam "Rapier," the Standard "Vanguard III," and the latest Ford models, the "Three Graces."

Before discussing the question of the probable sales appeal of British cars we propose to give a short description of the characteristics of the foreign makes and their effect on the mind of the Swiss customers. Starting with American cars, we note that the U.S.A., which, before the war and up to 1948, supplied about 40 per cent of the Swiss automobile market, has gradually lost ground to Continental competitors and now account for only 10·6 per cent of Swiss motor imports. The reasons for this considerable drop are explained by the fact that the end of the war left the Continental motor industry in a state of almost complete disintegration, and British and American cars were the only makes available for immediate import. Although it was obvious that, with the re-emergence of France, Germany and Italy as major motor-producing countries, part of the dominant position of the U.S.A. would be lost, the drop in American imports into Switzerland was actually far greater than expected. There is no doubt that the powerful, roomy and comfortable American car represents excellent value for money and, especially when fitted with such refinements as automatic transmission, servo-steering, and air conditioning, affords ideal motoring even in severe operational conditions. Purely economical considerations, lack of garage and parking space and in particular the high price of petrol, road tax and insurance premiums, were responsible for the trend, now quite general in all European countries, towards smaller cars with engines of something between 1 litre and 2 litres cylinder capacity. The greatly improved performance of this class of cars, which now accounts for about 58 per cent of all new Swiss registrations, places the American cars in the category of a desirable though not essential luxury. While still commanding a noticeable market, it seems that their sales appeal is diminishing. The leading makes, Chevrolet, Plymouth and Ford, are distributed by the American parent companies, which maintain efficient sales and service organisations.

Fig. 3—The Renault "Dauphine" has a water-cooled 850cc engine between the rear wheels

France, the second on the list of car importers to Switzerland, last year slightly increased her sales, though one of her most popular cars, the front-wheel-driven Citroen 11 c.v., which has been built for more than twenty years without any major alterations, has been losing its sales appeal because the styling is considered out of date. The new type D.S.19 which was one of the great attractions at last year's Paris Salon and at the London Motor Show is not yet in full production. To judge from the interest shown by the Swiss public in Geneva, it can be expected that this hyper-modern design may well prove a best-seller; some scepticism is being voiced as to the probable reliability of the rather complicated hydraulic system which controls the springing, the gear change and the servo-operation of the steering and the brakes. Sales in Switzerland are progressing satisfactorily of the unorthodox Citroen 2 c.v., powered by a horizontally-opposed air-cooled two-cylinder engine, the cylinder capacity of which has lately been increased to 425 cc. In spite of the ugly, utilitarian body style the demand for this practical and economic run-about has outpaced the manufacturing capacity of the firm.

The most popular French make in Switzerland is Renault, represented by the 2-litre "Frégate" and the rear-engined 750 cc type 4 c.v., which is now optionally available with the automatic Ferlec electromagnetic clutch. The latest addition to the range of Renault small cars is the "Dauphine," which, at its first public appearance at the Geneva Salon, was one of the main centres of interest at the show. The "Dauphine," seen in Fig. 3, basically similar in its conception to the 4 c.v., is a well proportioned car of pleasing appearance, fitted with an 850 cc o.h.v. engine of 58mm bore and 80mm stroke which develops 26 h.p. at 4250 r.p.m. The engine forms one self-contained unit with the synchronised three-speed gearbox and the final drive, the torque being transmitted to

Fig. 1—Nose of the Viberti "Golden Dolphin" coach, intended to be powered by a Fiat gas turbine and carry 18 passengers at speeds up to 125 m.p.h.

Fig. 2—Forward control has been adopted for the "Multipla" Fiat 600. The rear seats fold to lie flat with the door sills

the coil-sprung rear wheels through universally jointed half-shafts. Compared to the 4 c.v., the wheelbase has been increased by 7in and the front track by 1¼in, thus providing fairly comfortable accommodation for four people and a surprisingly spacious luggage compartment at the front. With a dry weight of about 12 cwt the car has a power-to-weight ratio of 42 h.p. per ton which, in conjunction with the independent all-wheel suspension, should provide ample flexibility as well as comfortable riding properties. A maximum speed of about 68 m.p.h. and an average fuel consumption of 40 m.p.g. are claimed. To judge from the interest shown by Swiss and also by foreign dealers, considerable sales are expected, though, for Swiss conditions, a four-speed gearbox would have been desirable.

Other French cars popular in Switzerland are the 1·3-litre Peugeot 203, the 1·3-litre Simca "Aronde," and the 2·3-litre "Versailles," the latter being the former Ford "Vedette" V-eight, which is now made by Simca, but distributed in Switzerland by the Swiss Ford organisation. Unlike the Citroen and Renault, these latter cars are of classical construction.

About 90 per cent of the 5780 Italian cars imported into Switzerland last year were supplied by Fiat, and the remainder by Alfa Romeo and Lancia. Fig. 1 illustrates a novel Italian coach. By far the most popular Italian car is the 1·2-litre "Nuova"

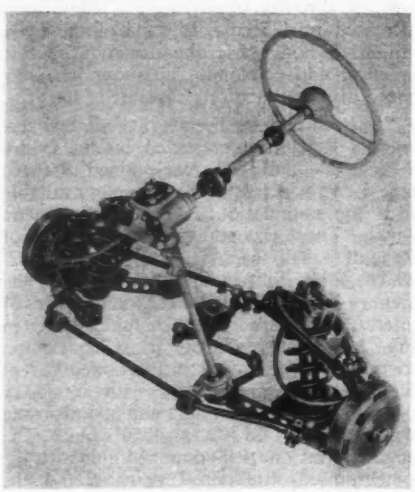


Fig. 4—Independent suspension by coil springs is used on the forward control "Multipla."

Fiat 1100, a small, but well-proportioned fast car of surprising flexibility and good hill climbing qualities. The rear-engined "600," first marketed last year as successor to the very popular two-seater "Topolino," represents in its conception a striking constrast to the basically orthodox design of the "1100." The car, exhibited at last year's London show and described in our report of November 4, 1955, is an example of optimum space utilisation within the limits set by a wheelbase of only 6ft 8in and a track of 3ft 10in. It also achieves the remarkable feats of accommodating four persons with reasonable comfort and providing fairly good riding and handling properties at speeds in excess of about 55 m.p.h. This attractive little four-seater model has now been supplemented by an equally ingenious dual-purpose vehicle, the Fiat "600" "Multipla," Fig. 2, first presented last January at the Brussels Salon. It has an integral all-steel body, 13in longer than that of the four-seater; the wheelbase is the same, but the front track is 3in wider. It has a bench front seat and four bucket seats at the rear which can be folded down to form a loading platform of about 19 square feet, capable of carrying a pay-load of 7 cwt. The engine-transmission unit and the rear suspension (apart from a different axle-ratio) is the same for either type, but the front suspension shown in Fig. 4 of the "Multipla" employs coil springs instead of the transverse leaf spring of the four-seater. As the front seat is shifted towards the front of the vehicle, the steering box has been mounted at the front panel almost level with the driver's knees; it carries a short steering column and the steering torque is transmitted from the box to the drop-arm in front of the two-piece track rod by means of a short shaft. The spare wheel is located inside next to the steering column.

This well-designed and not unattractive little vehicle represents a novel and, apparently, quite promising approach towards the problem of the small economic utility car. It was one of the main centres of interest at the show, and the manufacturers claimed that the export sales effected in Geneva exceeded their expectations.

(To be continued)

Institution of Naval Architects

ANNUAL SPRING MEETING

No. IV—(*Continued from page 377, April 20th*)

WE regret that, in last week's report of the proceedings, we inadvertently curtailed Mr. W. D. Rankin's remarks, and we therefore reproduce below this part of the discussion of Dr. Wells' paper on "The Brittle Fracture Strengths of Welded Steel Plates."

Mr. W. D. Rankin: The concept of a "calamity" temperature is novel and requires further investigation to substantiate its relation to service behaviour.

Generally, in ships or other welded structures which have failed, the drop in temperature so often associated with casualties occurs while the structure is under its working stress. This working stress may not be static, but may be fluctuating considerably about its mean. In the Wells test the sequence of applying the load and cooling is reversed in relation to that occurring in most service casualties. However, this is not always so, and it remains to be seen whether there is indeed a difference in the results obtained by cooling before applying the load and those obtained in applying the stress before cooling.

Mathematical analysis of the results shows that specimen *G* is one in which, if the strain energy release rate at arrest had been slightly higher, propagation would have been complete. Another way of expressing this is that if the applied stress required to initiate fracture had been slightly greater, propagation would have been complete. This is demonstrated clearly if the results shown in Fig. 8 of Dr. Wells' paper are plotted together with the Robertson curve for this steel. Point *G* lies fairly close to the horizontal position of the Robertson line. According to this line, an increase in stress of only 1½ tons per square inch would have been sufficient to ensure full propagation of the fracture. It can also be seen that no arrests have occurred above the stress level defined by the horizontal portion of the Robertson line. Conversely, where initiation has occurred under an applied stress greater than the stress shown by this line, propagation has been complete. Thus the idea of a limiting stress at any given temperature, below which propagation will not occur, is supported by Dr. Wells' mathematical analysis.

Professor A. M. Robb was in the chair on Wednesday, when the second paper of the morning was presented and this was:

CONTRA-ROTATING PROPELLERS

By Dr. J. D. van Manen and Dipl.-Ing. A. Sentic

Synopsis

A brief description of the velocity field induced by a propeller is given and then the results obtained from open-water tests with systematically varied contra-rotating propellers of the B3-65 type are discussed. The results are given in a $B_p - \delta$ diagram with the aid of which it is possible to derive a survey of the efficiencies of contra-rotating propeller systems. This diagram also provides data concerning optimum diameters and pitch ratios of front and rear propellers. An analysis with the aid of circulation theory of the experimental results shows that with a distance of $0{\cdot}37D$ between the propellers the axial induced velocity generated by the rear propeller is, in way of the front propeller, about 30 per cent of the value it has infinitely far downstream of the rear propeller. A method based on circulation theory is developed, by which contra-rotating propellers can be designed provided that they are of optimum diameter.

Discussion

Mr. Stevens: There are so many factors of action and interaction between two propellers that one would have thought that effective design would be extremely difficult, but apparently after about two shots at this process of circulation one can arrive at a reasonably good design. Another item is that in comparing the efficiency of contra-rotating propellers with the ordinary twin-screw arrangement we have to take into account a larger shaft and boss, and I wonder to what extent that might come in as a factor against the comparison.

The interaction between fore and aft propellers might introduce some additional likelihood of cavitation, and I assume one should be chary about adopting a contra-rotating system where interaction is likely to give cavitation.

Mr. A. Silverleaf: This is a practical paper of forward-looking interest, and is the clearest account yet published of contra-action in the propeller system; it gives the first experimental results published and presents the first straightforward design method to deal with propellers. The authors point out the limitations of their experimental results; nevertheless, the trends are fairly clearly defined by these limited results. A good deal of work is necessary in further experiments to see how closely those trends are confirmed when the range is extended; nevertheless, we have a lot of solid data.

Two reasons for studying contra-rotating propellers: the subject is of general scientific and technical interest that in itself is probably sufficient justification for the work, and it has considerable practical application. He would be a bold man who would suggest that we are likely in the foreseeable future to install contra-rotating propellers on the normal merchant vessels, particularly of the twin screw type; however, there will be a number of instances where contra-rotating propellers could with advantage be used on certain specialised types of vessels. A practical problem in connection with propulsion

in the next twenty-five years is that powers will increase, but propeller diameters will not increase. Diameters are fixed by ship requirements, and harbours and shallow waters will not become deeper. There are projects where, for example, the Harwich/Hook of Holland trip can be transformed from an all-night service to one of one hour or so ; a speed of 60 knots is not out of the question. I do not believe the difficulties in respect of propulsion are insuperable. I suggest that we shall be concerned with problems such as cavitation breakdown and with smooth-running propellers, and in those particular aspects the ideas which the paper puts forward may be developed.

I do not think contra-rotating propellers will necessarily be adopted in the form this paper may suggest ; there are quite a lot of refinements which can be made.

Dr. J. F. Leathard : The authors refer to the interference factor. I believe this is the normal Goldstein or Prandtl factor. I have always understood the Goldstein or Prandtl factor governs the type of blade where you have a series of vortex sheets shed by the blade from the root outwards, and due to this there is an influence on the general distribution of velocities in the wake ; there is a spilling over towards the centre of the blade, over the tip and round into the next gap. The spilling effect introduces the conception which comes from the Goldstein or Prandtl factor. If another propeller is put in I am not sure what will be its influence on this interference factor, and I wonder if the authors have actually used the Goldstein factor as calculated for a single propeller or have corrected it to take account of the fact that there is some additional interference effect on the wake. That would apply primarily, of course, to the front propeller and not to the rear propeller.

In some cases you could reduce the propeller diameter if you put in contra propellers, and still get the same thrust as before ; but I appreciate that difficulties would be involved in designing machinery to suit, and there may be a loss of efficiency which will counterbalance the improved propulsion efficiency.

Professor E. V. Telfer : I would emphasise how keen was the late General Rota in exploring the possibilities of contra-rotating propellers. The bibliography at the end of the paper might be increased by reference to a paper by Colonel Rotunda, given before this Institution in 1934, and in which full details of a training ship were given. It is interesting that, whilst that was a two-bladed application, it was claimed in that paper that an improvement of 20 per cent over the efficiency of the ordinary propeller was obtained. It was this order of figure that spurred General Rota to further investigations of this subject, and I therefore emphasise that there is some progress still to be found with the contra-rotating propellers, and I hope that the tanks, and B.S.R.A., will look into the problem.

This is not the first paper to give experimental data on contra-rotating propellers ; a fine investigation was made by Schaffran and was published about 1925. He was very interested then in airscrews, and tried propellers of airscrew type in water. That work would be a useful reference to include in the present paper.

Coming to the possibilities of the future application of contra-rotating propellers to single-screw ships, quite apart from the complication of the design, there is the fact that we are already tapping, by means of correctly designed streamlined rudders behind a single screw, a lot of the propeller losses. But the most interesting thing about the experiments by General Rota was that it appeared that the thrust deduction for a given total thrust was only half the value with contra-rotating propellers compared with a normal propeller. Apart from that, if you can design at smaller diameters it would be extremely useful. The authors have made out an excellent case for a more detailed investigation of the possibilities of the contra-rotating propeller in the light of modern knowledge. Let us see the potentialities, and if they are as helpful as some of us think, then this paper will have proved to have been very timely and have opened up a new field of research in the propulsion of ships.

Dr. R. W. L. Gawn was in the chair when the meetings were resumed in the afternoon of Thursday, March 22nd, when the following paper was presented :—

ASPECTS OF SHIP VIBRATION INDUCED BY TWIN PROPELLERS

By J. W. Ramsay, B.Sc. (Eng.)

SYNOPSIS

The character of vibration in a fast turbine-driven ship depends partly on the magnitude and frequency of the forces imposed upon it by the geometry and location of the propellers, and partly upon the elasticity of the hull structure, and these two aspects are discussed with reference to twin-screw warships. The forces exciting vibration are believed to be predominantly hull pressure forces in the vertical direction and mixed wake forces athwartships, and preliminary theoretical and experimental results are given concerning the magnitude of the pressure forces. The response of the hull to such forces is discussed based on a vibration generator survey of a destroyer and calculations of the first five natural frequencies of vertical flexural vibration.

DISCUSSION

Professor S. J. Palmer : Mr. Ramsay has brought out some very useful data on the forces of vibration, and has pointed out that vibrations in warships are becoming more troublesome. This is not because there has been any increase in the way the ships are vibrating, but because they are carrying more sensitive equipment which is not able to withstand these vibrations. Any vibration of the supporting structure is magnified many times at the top of masts, and it is not uncommon to find that some aerials are shaken off when the vibration is at its worst.

These vibrations are generally excited by the periodic forces arising from the propeller blades cutting through the high wake zone near the hull, and invariably the forced vibration has a frequency equal to the revolutions per minute times the number of blades.

What can the ship designer do to reduce these vibrations. The naval architect shapes the ship's lines so that the flow past the propeller is as uniform as possible, and also keeps a minimum clearance between the propeller and the hull, based on experience. The reduction in propulsive efficiency with smaller propeller diameters limits the amount of clearance that can be allowed. But the form of the ship, the diameter of the propeller and the revolutions per minute of the shaft have to be decided before the structural design of the hull can be completed, so that by the time the natural frequencies of the hull can be calculated the only relevant variable still to be settled is the number of propeller blades. I appreciate that accurate methods for forecasting the natural frequencies lead to a better understanding of the mechanism of hull vibration ; but I ask whether Mr. Ramsay agrees that in practice the calculation of these values for a new design can be used only to decide the number of blades on the propellers.

Mr. J. L. Kent : With regard to merchant ships with either twin or single propellers, if you watch a model closely with the waves passing over the propeller, they are short in length, but fairly steep, and as the crest passes over the top of the propeller both the thrust and the torque drop, while as the trough passes over, the thrust and the torque rise. When you come to larger waves and twin-screw vessels, as a propeller comes towards the surface the thrust goes up and, in many ships I have been on, the vibration starts ; then, as the propeller goes down, the vibration stops.

Mr. Stevens : The author appears to have established a case for working with as many blades as possible, and by using an infinite number of infinitely thin blades you think you may dispense with vibration altogether. But practical blades are not infinitely thin, and there must be a limit to the number of blades which can be used beneficially.

I think the first urge to vary the number of blades in order to reduce vibration did not come from the vibration of a ship's hull, but was suggested by the need to do something about resonant vibrations which occur in the shafting, gear and propeller combination, and it seems to me that the best solution of the hull vibration problem may not necessarily be the best from the machinery aspect.

From Figs. 4 and 5 in the paper there is with increasing clearance up to 20 per cent a reduction of pressure on the hull. The pressure induced by a three-bladed propeller is about three times that induced by the five-bladed propeller at 20 per cent clearance, or, alternatively, we could work to about half the clearance and induce the same pressure with five blades as with three.

The author has plotted his results in the form of hull clearance as a percentage of the diameter of the propeller. Does he regard that as a good general criterion ? It has been suggested that other factors ought to be included in determining hull clearance, and one of them is the length of the ship as it affects the thickness of the boundary layer. The rather surprisingly small effect of the boundary layer as shown in Fig. 3 may have something to do with that.

The author says that wide blades are regarded as having several beneficial effects, but that the possibility of adopting them is very seriously limited by reason of questions concerning manufacture, fitting and maintenance, and by the associated drop in propeller efficiency. For those reasons I doubt that there will be willingness to adopt wider blades.

Mr. A. Silverleaf : This is a paper which gives practical answers to practical questions. I have been concerned to know what would be the slope of the curves showing the calculated variation in harmonic pressure with tip clearance (Figs. 4 and 5) ; it is the slope, rather than the relative values, that matters. It gives a clear indication of whether there is any significant advantage to be achieved by increasing blade tip clearance from (say) 0·2 to 0·25 of the diameter.

The ship results seem to be clear and detailed, and capable of leading to interesting conclusions. I notice that the residual amplitude at the higher frequencies, up to 500–750 cycles per minute, are much less at the bows than at the stern, and I ascribe it to the attenuation of the higher modes along the length of the ship. It is a phenomenon which frequently occurs.

The author has noticed no depth of water effect. I am not surprised, because with a depth of water of 30ft to 40ft, and I presume the draught is 10ft to 12ft, I would not expect significant differences, although I doubt whether depth of water effect is solely a depth/draught factor.

(*To be continued*)

Hackney "B" Power Station

HACKNEY "B" power station (London Division, C.E.A.), which was opened on April 14th by the Mayor of Hackney, contains provision for a first stage of three 30MW turbo-alternator sets. The possibility of abandoning the older station, Hackney "A," with its total capacity of 91MW, at some future date has been envisaged by arranging that the new station should be capable of being developed to an ultimate capacity of 150MW from five 30MW sets.

Additional land required for a coal stockyard as part of the new development was acquired on the opposite side of Hackney Navigation Cut by transferring a small part of Hackney Marsh, by arrangement with the London County Council. An equivalent piece of land adjoining the Marsh was obtained by the Central Electricity Authority and handed over to the London County Council as one of the conditions for this transfer.

The station foundations are on piles, bearing on a layer of block pebbles cemented in position at about 25ft depth. The circulating water culverts are built directly on the block pebbles. From a cooling water intake 2250ft to the north of the station, a culvert is built in open cut to a tunnel (made of cast iron segments with concrete backing) under Lea Bridge Road. To avoid raising the river water temperature at periods of low flow a mechanical-draught cooling tower is built on the east side of the cut. This tower is a wooden structure with eight compartments, each containing an induced-draught fan of 20ft 9in diameter, driven by a 55 h.p. motor at 116 r.p.m. The water, which is spray cooled in the towers, is taken from the cut and delivered by two axial-flow pumps with a combined capacity of 2,250,000 gallons per hour, which is enough for cooling Nos. 1 and 2 turbines without drawing any water from the River Lea.

All the power station buildings have reinforced concrete frames, with the exception of the boiler house, which is steel framed. The 300ft chimney is of reinforced concrete, finished with stone paint, and has an acid-resisting brick lining, with 2in air space. The inside diameter of the chimney is reduced at the top to increase the gas velocity at discharge. The main axis of the station is roughly N.W.–S.E. Two 30MW turbo-alternators are installed in tandem in the turbine-house, which is designed to accommodate a third set to be commissioned in 1958. Each turbine is a two-cylinder machine with inlet steam conditions of 600 lb per square inch and 850 deg. Fah. The h.p. cylinder is anchored at the h.p. inlet bearing, so that the casing can expand on the bed plate at the exhaust end of this cylinder. Half-claw couplings between the h.p. and l.p. rotors allow for expansion of the h.p. rotor. Four stages of feed heating raise the final condensate temperature to 345 deg. Fah. at full load. A motor-driven feed pump serves each boiler and a standby turbine-driven feed pump of 50 per cent duty is started up automatically in the event of failure of feed pressure.

Each machine exhausts into a single-shell, double-water-compartment condenser which has a 25,000-square-foot cooling surface and is designed to maintain a vacuum of 28·55in Hg with a cooling water inlet temperature of 62·5 deg. Fah. Two axial-flow, vertical c.w. pumps supply cooling water to each condenser, no valves being required as the water supply is at a sensibly constant head.

A 34·3kVA air-cooled alternator with a direct-coupled exciter is coupled to each turbine. Generation is at 7·3kV to allow for voltage drop across the reactors which are connected to the London Electricity Board's 6·6kV system.

Steam for the initial installation of two 30MW sets is generated in two p.f. fired boilers, each designed for an output of 300,000 lb steam per hour at 625 lb per square inch and 865 deg. Fah. Three mills provide pulverised fuel to burners at the corners of each boiler, the burners being arranged to give tangential firing. Lighting up is done by oil-burning initiators fitted with automatic electrical igniters. Flame failure in the combustion chamber causes the initiators to enter the furnace automatically to restore stable conditions.

Control of steam temperature is effected by tilting the p.f. burners in the combustion chamber, the operation being under the automatic control of a "Multelec" regulator actuated from a thermocouple in the steam pipe. Automatic control of the boiler is provided and the facilities on the control panel include excessive-smoke indication and flame indication. All gas passes are cleaned by electrically operated soot blowers. Dust is removed from the flue gas outlet by electrostatic precipitators.

Hackney "B" power station. Behind the road bridge is the concrete-clad coaling bridge over the Hackney Navigation Cut. Two 30MW generating sets are installed, with provision for a third

Boiler make-up water is supplied by two central evaporation plants which are fed from the station wells or from the Metropolitan Water Board supply, after being softened by a base-exchange process.

Coal is unloaded from 125-ton barges in the Cut by grabs discharging into hoppers which are covered to minimise dust nuisance. A 200-ton-per-hour belt conveyor takes the coal from the wharfside and loads it into two elevators. There the coal is weighed and carried on belt conveyors to the boiler-house bunkers over magnetic separators to remove tramp iron. Alternatively, coal can be carried to the stockyard on the opposite bank of the Cut, via a bridge conveyor, and can be reclaimed by a reloader operating along the whole length of the stockyard.

Ash from each boiler is sluiced into a settling pit and stored in hoppers for disposal by lorry. Dust from the precipitators is at present transported by lorry after wetting, but it may prove to be saleable.

With the exception of the boiler feed pumps and the cooling tower pumps which are supplied at 6·6kV, all the electrical auxiliaries operate at 415V, three-phase, from works transformers. The high-voltage switchgear is controlled from the central control room, and is installed in sectional switch-houses and is protected by CO_2 fire-fighting equipment. Voltage regulators, batteries and other auxiliary plant are installed in the main switch-house.

The directive for the construction of Hackney "B" station was issued by the Central Electricity Board in 1947, and the station was designed by Mr. E. A. Mills, who was the borough electrical engineer, Hackney, from 1934–48. Constructional work was started, after the reconstitution of the electricity supply industry, in 1948 and then became the responsibility of the London Division of the Central Electricity Authority, under the control of Mr. H. V. Pugh. Messrs. L. G. Mouchel and Partners were retained as consultants for the buildings and civil engineering works.

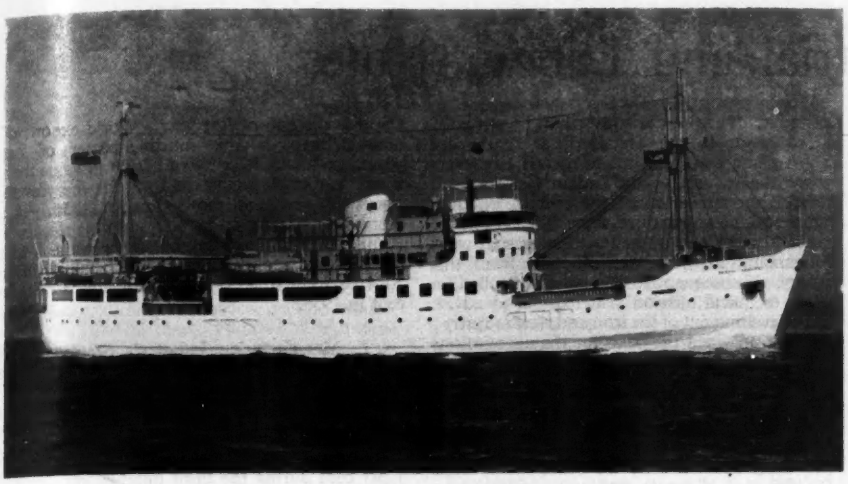
A list of the main contractors is appended here.

Main Contractors

Foundations, framework, cladding, chimney, canal bridge, J. L. Kier and Co., Ltd.; C.W. intake works, foundation works east of canal, John Morgan (London), Ltd.; structural steelwork, Horseley Bridge and Thos. Piggott, Ltd.; coal-handling plant, Mitchell Engineering, Ltd.; boiler plant, ash-handling plant, Simon-Carves, Ltd.; fans and air heaters, James Howden and Co., Ltd.; electrostatic precipitators, The Sturtevant Engineering Company, Ltd.; coal preparation and firing equipment, International Combustion, Ltd.; dust-handling plant, Davidson and Co., Ltd.; turbo-alternators, h.p. pipework, C. A. Parsons and Co., Ltd.; condensing plant, Worthington-Simpson, Ltd.; de-aerating plant, Hick, Hargreaves and Co., Ltd.; l.p. pipework, Shaw-Petrie, Ltd.; c.w. pipework, Aiton and Co., Ltd.; c.w. pumps, Vickers-Armstrongs, Ltd., Sigmund Pumps, Ltd.; c.w. screens and penstocks, F. W. Brackett and Co., Ltd.; boiler feed pumps, The Harland Engineering Company, Ltd.; auxiliary pumps, Sigmund Pumps, Ltd.; tanks, Whitt and Chambers, Ltd.; water softener, The Permutit Company, Ltd.; chlorination plant, Wallace and Tiernan, Ltd.; turbine house crane, Sir Wm. Arrol and Co., Ltd.; fire fighting plant, Mather and Platt, Ltd.; induced draught cooling tower, Head, Wrightson and Co., Ltd.; evaporating plant, Hick, Hargreaves and Co., Ltd.; 6600V switchgear, The British Thomson-Houston Company, Ltd., The General Electric Company, Ltd.; 415V switchgear, The English Electric Company, Ltd.; cables, The Aberdare Cable Company, Ltd., George E. Taylor and Co. (London), Ltd.; transformers, South Wales Switchgear, Ltd.; reactors, The British Thomson-Houston Company, Ltd.; batteries, The Edison Swan Electric Company, Ltd.; battery charging equipment, The Hackbridge and Hewittic Electrical Company, Ltd.

Association of Supervising Electrical Engineers.—At the annual dinner of the Association of Electrical Engineers, on April 6th, the toast of "The Electrical Industry" was proposed by the Earl of Verulam. Sir Claude Gibb, who responded, recalled the close connection that existed between living standards and consumption of electricity. It was not generally realised, he said, that if the nations of the world were listed in order of standards of living and of electricity consumption per head the two lists would coincide. Speaking of future developments in atomic energy, Sir Claude asserted that the decision of the Atomic Energy Authority and the Central Electricity Authority to concentrate on the development of the gas-cooled graphite-moderated reactor would very soon be proved to have been right for Great Britain. In overall economy gas-cooled reactor stations would compete with the best coal-fired stations in the 1960s and, compared with some more advanced reactors, they had the advantage of being inherently safe.

Drilling Machine for Rail Bond Holes.—A portable machine for drilling bond wire holes in rails is being made by Abtus Ltd., Vanden Court, Petty France, London, S.W.1. It is driven by a 1½ h.p. petrol engine and drills two holes simultaneously through the webs of standard 95 lb or 105 lb rails. The combined drill head and drive unit is slidably mounted on a tubular base incorporating rail grip hooks, and drilling pressure is applied by a long hand lever extending up from the frame.



The passenger and cargo ship "Seyyid Khalifa"

Passenger and Cargo Ship "Seyyid Khalifa"

OUR illustration shows the "Seyyid Khalifa," which has been built by Philip and Son, Ltd., of Dartmouth, to the order of the Crown Agents for Overseas Governments and Administrations. The ship was designed by the builders in association with the consulting engineers Flannery, Baggallay and Johnson, Ltd., for the Government of Zanzibar for the clove industry, and will operate an inter-island service between Zanzibar and Pemba and the ports of Kenya and Tanganyika.

The main particulars of the ship are:—Length between perpendiculars, 200ft; breadth moulded, 38ft; depth moulded to main deck, 15ft; gross tonnage, 1542; and net tonnage, 900. A trial speed of 13·4 knots was attained with the ship in the ballasted condition. Provision has been made for the ship to be used by the Sultan, for whom a suite is available, as a private yacht. On the boat deck there are cabins for nine first class passengers and a dining saloon, while sixteen second class passengers are accommodated on the shelter deck, together with their dining room. On the same deck are the engineers' cabins, those for the deck officers being located on the bridge deck, while the crew's quarters are situated aft on the main and shelter decks. The greater part of the main deck is arranged to take some 350 natives as deck passengers, since the ship will be required to transport about 30,000 pickers from Zanzibar to Pemba during the clove season.

There are two cargo holds, fitted with MacGregor hatch covers, having a total capacity of 500 tons, and for handling the cargo there are one 7-ton and four 3-ton derricks served by two 3-ton electric winches. Other deck machinery, all of which was supplied by Clarke, Chapman and Co., Ltd., includes an electric windlass and an electric capstan. Brown Brothers and Co., Ltd., manufactured the two ram electro-hydraulic telemotor controlled steering gear. A carbon dioxide fire extinguishing system is installed, the ship is mechanically ventilated throughout, and for lifesaving there are four 24ft aluminium alloy lifeboats, built by Viking Marine, Ltd. and carried in "Columbus" davits, and the requisite number of life rafts. Kelvin and Hughes (Marine), Ltd., provided the compasses and echo sounder, and the communications equipment was supplied by Marconi International Marine Communication Company, Ltd.

Propulsion is by two British Polar direct-reversing, two-stroke, normally aspirated, Mark M.46M diesel engines, each having six cylinders of 340mm bore by 570mm stroke and each rated to develop 1000 b.h.p. at 300 r.p.m. under tropical conditions. These engines have their own heat exchangers and are fresh-water cooled, the fresh-water circulation pump being engine driven, while the sea-water circulating pump is independently driven by an electric motor. As a standby for these pumps there are two 40 tons per hour pumps, one being electrically driven, the other being driven by a diesel engine which also drives an auxiliary air compressor. Other pumps include a ballast pump of 40 tons per hour capacity, engine-driven bilge pumps, and a 35 tons per hour emergency water pump.

Each main engine has an integral air compressor and starting air is stored at 350 lb per square inch in three large and two small receivers, the latter serving the two British Polar Mark K44.E diesel engines, each of which drives a 150kW generator manufactured by The General Electric Company, Ltd. For emergency purposes there is a self-contained 6kW diesel-driven generator set. Air-operated ejectors handle the ship's sewage, the air being taken from the main receivers and stored in two small receivers at a reduced pressure of 75 lb per square inch. Oil fuel is carried in two tanks, each of 45 tons capacity, arranged forward of the engine-room, and there is tank capacity for a total of 40 tons of domestic fresh water, while about 275 tons of fresh water ballast can be carried in the double bottom and peak tanks.

Hydraulic Tipping Gear for Road Vehicles

A TIPPING gear for vehicles, now being made in two models for heavy and medium duty, was recently demonstrated by Telehoist, Ltd., Swindon Lane, Cheltenham, Glos. The heavy-duty gear is designed for tipping vehicle bodies of up to 14 tons loading capacity, and the medium-duty gear handles bodies taking loads up to 8 tons. At the demonstration a medium-duty gear was shown in use with an 8 cubic yard steel body on an A.E.C. "Mercury" chassis, and tipping a 7 ton 10 cwt load of sand in about twenty seconds. There was also demonstrated an A.E.C. "Mammoth Major" six-wheeled chassis fitted with an 11 cubic yard dumper body and the heavy-duty gear. With this equipment a 13-ton load of sand was tipped in about twelve seconds, and this vehicle, with its body fully tilted, can be seen in the photograph we reproduce here.

These "Telelever" tipping gears, as they are known, are made as units complete with longitudinal frame members, one of which is fixed to the vehicle chassis and the other to the tipping body. The heavy-duty gear illustrated is fitted with twin, double-acting, hydraulic rams with a relatively short stroke, coupled to a linkage giving an angle of tip up to 70 deg. In this linkage a pair of thrust arms are hinged to the body subframe at the top and to a pair of bell crank links hinged to the lower subframe at the bottom. To the bottom links is attached a cross member which carries brackets forming the top attachment to the rams.

The subframe consists of a pair of 6 by 3in channels, mounted on top of the chassis. The rear of this subframe has bosses built into it to take a 2in shaft on which pivot the body tipping hinges, and near the centre is a pivot for the link gear. Across the front of the subframe is a strong member which takes the thrust from the lower end of the rams. This subframe is designed to take all the stresses imparted during tipping, so that none are transmitted to the chassis.

A large output pump for the hydraulic gear is mounted on a cradle attached to the chassis and is driven by a universally jointed shaft from a power take-off bolted to the side of the gearbox. The control for the power take-off is operated from the driver's cab. An oil reservoir with a capacity of approximately 19 gallons supplies the hydraulic system. A piston control valve fitted in a convenient position near the oil reservoir has an extension through to the cab to allow it to be operated by the driver. This valve has three positions—raise, hold and circulate, and lower.

The medium-duty tipping gear is operated by one single-acting hydraulic ram, which actuates the body through a similar form of compound linkage, to give a tipping angle of 50 deg. with a relatively short stroke. In this case, an annulus between the piston-rod and the cylinder forms an oil reservoir, and a rotary control valve mounted co-axially with the ram trunnion is connected to an operating lever in the driver's cab. The gear pump for this hydraulic system is designed to deliver 9·6 gallons per minute when running at 1000 r.p.m. against a pressure of 1000 lb per square inch.

The chassis subframe of this medium-capacity tipping gear is of "Z" shaped, pressed steel construction, and the body subframe rests in it to give the smallest possible mounting height. A substantial cross member in the subframe carries the ram pivot.

Heavy duty tipping gear fitted to a "Mammoth Major" with an 11 cubic yard body. Twin double-acting hydraulic rams, working in combination with a linkage system, give the body a 70 deg. tipping angle in 12 seconds and return it in 10 seconds

Industrial and Labour Notes

Iron and Steel

The British Iron and Steel Federation has published its annual report for 1955. Most of the information given in the report has already been published, but the document nevertheless constitutes a useful record of the all-round progress of this country's iron and steel industry. The report notes that last year the re-sale of the nationalised companies continued, and by the beginning of this year, about three-quarters of the industry, in terms of steel production and of employment, had been returned to private enterprise. It is also recorded that the industry is engaged in formulating plans for the next stage of development in the light of the expected requirements of steel in the early 1960s. The continuing programme of expansion raises problems of management no less than of materials and equipment, and during last year, it may be recalled, a report on management training in the steel industry was published. This report foreshadows central courses for managers from all sections of the industry to supplement the work done within the individual companies.

In a review of the industry's general development, the report says that the installation of new and larger units of plant led to further improvements in furnace productivity during 1955. The average steel production in an open hearth furnace last year was 60,100 tons, compared with 36,800 tons in 1946. The net rate of coke consumption in blast furnaces fell to 19·65 cwt last year, compared with 20 cwt in 1954 and 21·2 cwt in 1953, a reduction which represented an average saving of 1·55 cwt a ton of iron in two years. This has been accompanied by an increase in the use of coke breeze in sinter production equivalent to about 0·4 cwt a ton of iron. The report goes on to say that the development schemes, which are at present being carried out under the iron and steel industry's second post-war development plan, should be substantially completed by 1958. The British Iron and Steel Federation is now reviewing the next phase of development, and its advisory committee on development has been reconstituted for this purpose. The committee's first task has been to make a tentative estimate of the demand for steel in 1962, in consultation with the different sections of the industry. Companies have been asked for a preliminary indication of their general intentions or ideas for future development; they have also been asked for estimates of their likely steel production in 1962 and of their consequential requirements of labour and the principal raw materials.

India's Iron and Steel Industry

A few weeks ago an announcement was made about British participation in the construction and equipment of an iron and steel works for the Government of India. The cost of this project is put at about £80,000,000, and the works will have an initial capacity in excess of 1,000,000 ingot tons a year.

More details have now been supplied of the work to be undertaken by the British consortium which operates under the title Indian Steelworks Construction Company, Ltd. The consortium includes the following firms: Davy and United Engineering Company, Ltd., Head Wrightson and Co., Ltd., Simon-Carves, Ltd., and The Wellman Smith Owen Engineering Company, Ltd., who will be responsible for the engineering and supply of mechanical plant and equipment for the principal sections; British Thomson-Houston Company, Ltd., The English Electric Company, Ltd., General Electric Company, Ltd., and Metropolitan-Vickers Electrical Export Company, Ltd., who will provide the electrical equipment; Joseph Parks and Son, Ltd., Sir William Arrol and Co., Ltd., Dorman Long (Bridge and Engineering), Ltd., and Cleveland Bridge and Engineering Company, Ltd., who will undertake the fabrication of structural steel for buildings; and The Cementation Company, Ltd., who will carry out all the civil engineering work at the site at Durgapur, on the River Damodar. The present consortium is, virtually, the successor to the Metallurgical Equipment Export Company, Ltd., which, nearly two years ago at the request of the Indian Government, provided an indication of the cost of building a works with a capacity of some 700,000 tons of structural steel a year, and also suggested ways of financing the purchase of plant from this country. Subsequently, it will be recalled, a British technical mission visited India to advise on the development of the iron and steel industry; its report provided the basis for the negotiations between the Government of India and the Indian Steelworks Construction Company, Ltd., which began last October, and which have led to the present agreement.

As stated above, the plant at Durgapur has been designed to ensure an annual output of 1,000,000 tons of ingots, and up to 350,000 tons of foundry pig for sale. But the capacities of the coke oven, blast furnace and steel melting sections, and the primary rolling mills will be adequate for the production of 1,250,000 tons of ingots. Moreover, the general layout and the plant have been planned to allow for convenient doubling of the production. A tentative construction programme provides for the completion, by June 1959, of the first coke oven battery, first blast furnace and pig casting machines, with the necessary services and part of the workshops. The second stage, to be completed by the end of 1959, includes a second coke oven battery and a second blast furnace, part of the steel plant and the rolling mill up to billet mill stage. The final part of the work, including a third battery of coke ovens, a third blast furnace, the remainder of the workshops, steel plant and rolling mills, is expected to be complete by December 1960, and early in the following year, a wheel, tyre and axle plant should be ready for operation.

Overseas Trade

The Board of Trade says that, following the normal seasonal pattern, the United Kingdom's exports and imports in March were higher than in the preceding month. The final figures for March show the value of exports as £271,300,000, which was £3,500,000 above the highest monthly total previously registered last October. The latest increase was shared fairly evenly among most manufacturers, but it is stated that exports of aircraft and aircraft parts in March were particularly high at nearly £11,000,000.

Imports in March amounted to £330,200,000, the increase of £21,000,000 between February and March being a good deal less than between the comparable months of preceding years. But the Board of Trade says it is clear that the three weeks' stoppage of work in Australian ports at the end of January and early February seriously affected import arrivals from that country in March, which were probably between £7,000,000 and £8,000,000 lower than might otherwise have been expected. Similarly, the general strike in Finland in the first half of March reduced imports from that country. Furthermore, there was little sign that much of the delay to shipments caused by bad weather, which affected imports in February, especially from the Baltic area, was made good in March. In both the last two months, therefore, the Board of Trade suggests, imports have been somewhat reduced by exceptional causes and must be expected to show some repercussion in later months. Re-exports in March were valued at £13,300,000, and the visible trade deficit fell to £45,500,000.

In the first quarter of this year, the value of the United Kingdom's exports was 4½ per cent higher than in the corresponding period of 1955. Export prices rose by about 5 per cent, and there was little change in the volume of shipments. In its statement, the Board of Trade points out that figures of world trade for the first quarter of this year are not yet available, and that the figures for the fourth quarter of 1955 are only preliminary ones. These latter suggest, however, that there was no slackening in the expansion towards the end of last year. World exports of manufactures in the fourth quarter of last year were about 16 per cent higher in value than a year earlier, bringing the total for the year to about 13 per cent more than in 1954. But despite the increase in the absolute level of United Kingdom exports, her share in the world markets has continued to contract, falling from 20·4 per cent in 1954 to an estimated 19·8 per cent in 1955.

Manufacturing Industry's Stocks

The Board of Trade's latest inquiry into the total value of stocks and work in progress in manufacturing industry shows that there was an increase of 2 per cent during the final quarter of last year. This compared with an increase of 3 per cent during the third quarter and was, in fact, the smallest quarterly increase last year. At the end of last year, the index number (December 1954=100) for the value of stocks and work in progress was 113. The Board of Trade says that companies operating in the metal manufacturing and metal using trades accounted for a large part of the increase last year.

The A.E.U. National Committee

The annual conference of the Amalgamated Engineering Union's national committee is being held this week at Eastbourne. It began on Monday morning with a presidential address by Mr. Robert Openshaw who spoke about the demand for a shorter working week, without loss of pay, in the engineering industry.

Mr. Openshaw asserted that the principle of the forty-hour week had been the union's policy for a long time. He went on to say that the shorter working week should be regarded as the "safety valve" to the evolutionary processes of automation. It was known that in the U.S.A. there were instances in the automobile industry where a thirty-five hour week had been worked since 1947. It would seem, Mr. Openshaw remarked, that the industrial safety valve worked satisfactorily there, and he saw no reason why, with the development of automation, the forty-hour week should not be achieved in the not too distant future in this country. About wages, Mr. Openshaw said that all trade unionists were aware of the dangers of inflation. Claims were made and, with longer periods of negotiation between claim and settlement, the amount eventually conceded became insufficient to have any lasting effect on a worker's household economy. Consequently, a further claim became necessary. Engineering workers, Mr. Openshaw stated, did not want high wages, but enough purchasing power to give a fair return for their efforts.

At Tuesday's session of the conference, a resolution was carried in support of a "plan for automation." This suggests that the plan must be considered as the union's official policy. The plan urges that no firm should introduce automation without consulting the union, and that there should be no redundancy. Workers displaced because of automation, it is argued, should be given full wages until other work is found for them in the factory. The plan then declares that increases in productivity due to automation should be reflected in increased earnings. It goes on to advocate technical training in automation, and to urge that individual employers should tell district union committees and shop stewards their plans for automation. Finally, the plan says that there should be discussions between the A.E.U. and engineering employers' organisations with a view to the establishment of a committee representing trade unions, employers and the Government to "control the introduction and scope of automation." It is understood that the resolution about the plan was carried despite an expression of opinion that it was too early for the A.E.U. to formulate a policy on the matter. The union is to hold a conference later in the year to consider a report from its executive council on automation.

Continental Engineering News

The Expansion of Delft Technical University

Like other universities and institutions of higher education, Delft Technical University, which last year celebrated its jubilee, was faced after the war with the need to fill the increasing demands of industry for graduate engineers. Side by side went the necessity to provide for more industrial research—some of the laboratories of T.N.O. (Organisation for Industrial Research) are sited there—and superimposed on these more long-term problems was the question of accommodating the large number of students who sought admission in the immediate post-war period.

While the first plans made after 1945 allowed for a population of 3500 students, experience since that time has made it likely that the number will be at least 5000. Although a second technical university at Eindhoven is expected to take 1000 students by 1965, it is now considered that a total of 6000 engineering students are in fact not enough for the requirements of the Netherlands.

The expansion of Delft Technical University is taking place mainly in an area of 35 hectares known as the "Wippolder Complex," approximately south of the town centre.* In the first stage some 23 hectares is being built upon, the remainder being held in reserve. Already completed are the central workshop with its metrological section, and the ships' tank, also the wind tunnel, as well as the boiler-house, which will eventually be combined with the combustion and heat transfer laboratory, while other parts, such as the ships' laboratory, are nearing completion.

The shipbuilding laboratory is the second laboratory of this kind in Holland, the first one, at Wageningen, being for the benefit of shipowners and shipbuilders, while the Delft laboratory is to carry out basic research and to train students. Among the facilities of the Delft laboratory are a towing tank, a flow channel, and a cavitation tunnel.

Built for resistance and propulsion tests on models up to 10ft in length, the towing tank is 320ft long, 14ft wide, and has a maximum water depth of 9ft. Maximum speed of the carriage is 25ft per second. A pneumatic wave machine for generating regular and irregular waves up to 20ft long will be installed. By means of the wave generator researches can be carried out into the motions of a ship in a seaway.

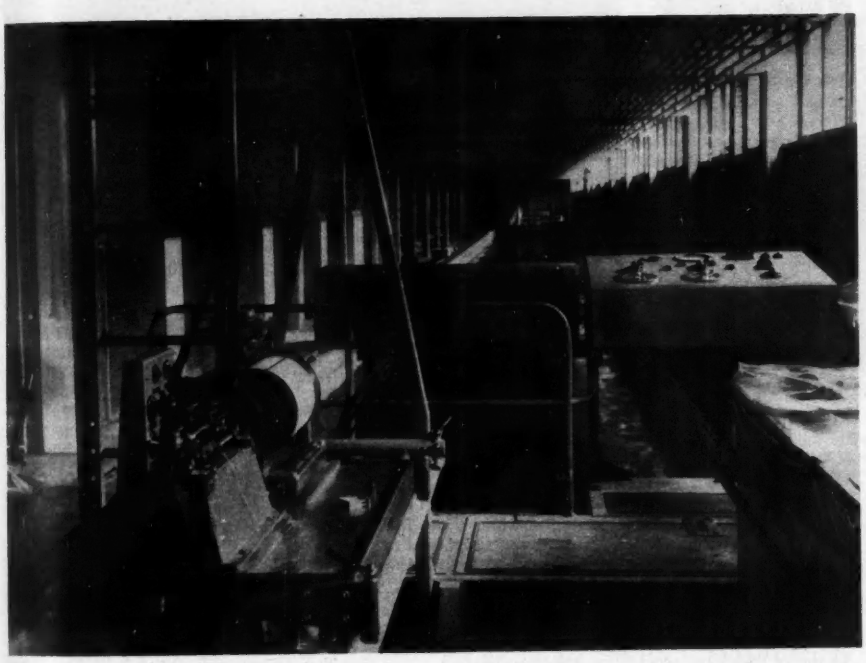
The flow channel will make possible the investigation of the movement of small draught vessels in rivers and channels, a field which is of particular importance in Holland, especially for the navigation of the Rhine. Leading dimensions of the channel are : length, 150ft; width, 9ft 2in ; maximum depth of water, 1ft 8in. The maximum speed of the water, for maximum depth, is 3ft per second ; the maximum speed of the carriage 8ft per second.

The cavitation tunnel has a test section 1ft square, with a maximum water speed at this section of 33ft per second, the minimum cavitation number being 0·4. By means of a honeycomb fitted with valves which allow the flow through each compartment to be adjusted, the velocity field can be made similar to that behind a ship.

* A full description of the "Wippolder" scheme is contained in the Jubilee edition of *De Ingenieur*, September 23, 1955.

Television and Ultra-Short-Wave Transmitter, Stuttgart

In our issue of January 13th, page 64, we described the construction of the television tower on the Hoher Bopser, near Stuttgart.



Towing tank at Delft University, seen from the carriage. The tank is 320ft long and the maximum carriage speed is 25ft per second

We have now received details of the electrical equipment installed in the tower. It will be recalled that the tower stands 210m high, including a 52m high lattice girder mast which, on its top portion, carries the television aerial system. This consists of sixteen octuple units arranged on four levels, and has the effect of concentrating the radiated energy in the horizontal plane, while emitting it equally in all directions. Below the television aerial, an ultra-short-wave aerial, also omnidirectional, is fitted within the girder. This consists of six cubical antennæ arranged one above the other.

The building at the top of the tower comprises four storeys ; the lowest one houses the transmitter for band III, which has been in operation since October 29, 1955. The transmitter occupies half the available space, so that there is room for a further television transmitter, e.g. for bands IV or V. As an advantage of placing the transmitter so close to the aerial it is stated that cable losses due to icing up will be minimised. Such losses could be up to 20 per cent of the transmitted energy for a tower of this height. The station sends out 10kW, but is equivalent to a 100kW transmitter without directional aerials.

Video signals are received by cable from the telecommunications tower on the neighbouring Frauenkopf mountains, which forms part of the German television network. After demodulation in the post office transfer station situated in a building near the foot of the tower, the picture is transmitted at video-frequency by means of a special cable to the station at the top of the tower. By means of two monitoring sets in the station, the quality of both the incoming and the outgoing picture can be checked. A regenerator makes it possible to adjust picture faults due to the long distance of transmission.

While the picture transmitter is amplitude-modulated the sound transmitter is frequency-modulated. It is situated near the foot of the tower and connected by a 210m long cable to its aerial. Transmitter power is 3kW. The building will also eventually house the two 10kW transmitters of Süddeutscher Rundfunk, Stuttgart, which are at present in the buildings of the former Degerloch transmitter station. The new station will supply the programmes of all other ultra-short-wave and small medium-wave transmitters of the S.D.R. These programmes come by cable from the broadcasting house in the Neckarstrasse. In addition to the actual transmitting equipment, there is additional equipment such as two diesel generator sets for emergency use, one for the transmitter and one for the lifts and lighting of the tower. The station comprises a workshop, measurements laboratory, stores, and a garage for the service vans which are used in the maintenance of subsidiary transmitters on other sites. There is also a high-voltage grid substation, water and drainage pumps, and heating and air-conditioning equipment for the tower, as well as for the building itself.

Motorways in Western Europe

The Autobahn system of the German Federal Republic totals some 1290 miles and represents more than 75 per cent of the West European total of motorways with four or more lanes, limited access, and opposite traffic streams separated. Austria possesses 6 miles of this kind of highway, Belgium 146, France 42, the Netherlands 192, and Italy 18. Some 180 to 240 miles are to be constructed in continental countries of Western Europe during the next few years, two-thirds of this mileage being in the Federal Republic.

In order to increase safety on the German Autobahnen, the telephone system along these highways is being extended at the rate of 120 miles of road per year. At present, there are 600 telephone stations along 570 miles of road. It is hoped to complete the work of installation by 1961.

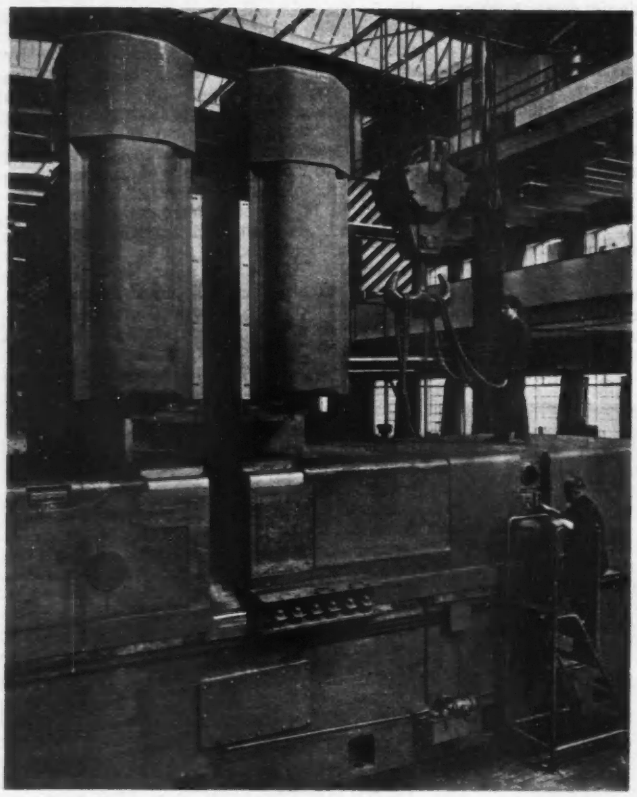
Total highway revenue in the German Federal Republic during the fiscal year 1953–54 amounted to DM. 2590 million. Expenditure in the same period totalled DM. 1796 million, or 70 per cent of revenue. The income and expenditure was allocated between the various agencies as follows: The Federal Government received DM. 1083 million in road taxes and spent DM. 293 million (27 per cent) ; the Laender received DM. 581 million and spent DM. 576 million, while communes and towns received DM. 513 million and spent DM. 1115 million, an excess of DM. 602 million.

Motor vehicle traffic on German highways is reported to have increased by 60 per cent during the last two years, with an increase on Federal roads of 45 per cent. This rate of increase is anticipated to continue.

Large Butt-Welding Machine

What is claimed to be the largest butt-welding machine built so far, is being completed at present for Klöckner Georgsmarienwerke, Osnabrück. The machine is capable of welding cross sections up to 40,000 square millimetres in area, and is intended for the manufacture of railway crossings, points and similar items.

Our accompanying illustration shows the welding machine during works assembly at the maker's factory, the Maschinen-und Apparatewerk Nurnberg, of Siemens-Schuckert-Werke. Weighing a total of 150 tons, it is 8m long, 3m wide, and 6m high, of which 4·6m will eventually extend above floor level. It can exert clamping forces of 180 tons at each clamp, and can compress the joint to be welded with a force of up to 120 tons, by means of hydraulic cylinders operated by water at a pressure of 250 atmospheres. Short-circuit currents up to 100,000A are used. On the left is the stationary clamping cylinder, while the movable cylinder is on the right, the two being electrically insulated from each other. On pressing the starting button, the clamped workpieces are automatically brought together and again separated to strike an arc which heats the workpieces to about 1300 deg. Cent. and also burns off any surface impurities. When this has been done, the current is switched off and the workpieces are brought together with great force, thus completing the weld.



Butt-welding machine for sections up to 40,000 square millimetres. The clamping pressure is 180 tons, the forging pressure 120 tons. Currents up to 100,000A are employed

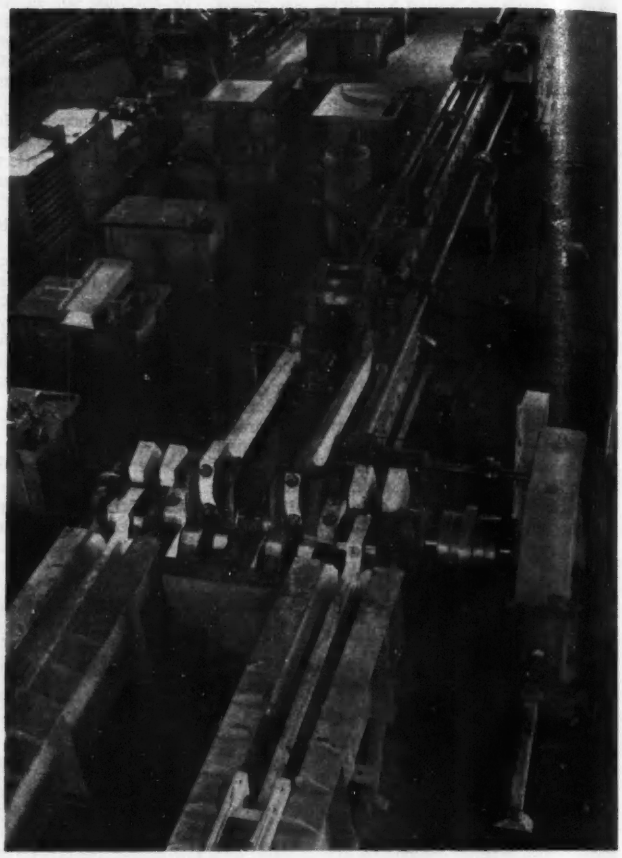
Cold Reducing Tube Mill

The " Pilger " mill for the cold rolling of seamless tubes goes back to 1931 when patents for such a machine were granted to the American engineer Neuberth. Shortly afterwards the process was taken over by the Tube Reducing Corporation, Wallington, New Jersey, and was introduced in Europe in 1935 by Maschinenfabrik Meer.

Cold reducing of tubes is now employed for carbon and alloy steels, such as chrome and stainless steels, as well as for non-ferrous metals. The method is suitable for producing non-circular or tapering sections, tapering wall-thicknesses, and tubes with thickened portions such as are used for " T " welds.

The machine here illustrated is manufactured by Mannesmann-Meer Aktiengesellschaft, of München-Gladbach, and is capable of reducing tubes of up to 2½in outside diameter. By counterbalancing the rather heavy reciprocating masses it has been found possible to increase the speed from about 100 to 180 r.p.m., with a consequent raising of output.

In the " Pilger " process, the tube is passed between two composite rolls which have been profiled to the required section over half the roll circumference. The rolling grooves are tapered. The rolls are mounted in a frame which is reciprocated by a crank mechanism while the rolls are rotated by the rack and pinion arrangement seen in the illustration. In order to prevent an uneven collapse of the tube walls, a conical mandrel is inserted. At the beginning and end of each stroke the roll grooves are enlarged so that the workpiece is released. At the moment the workpiece and mandrel are free at the beginning of the cycle, the tube is fed forward by a predetermined amount, and both tube and mandrel are rotated through about 60 deg. The fact that this feeding and turning may only occupy one-sixth of the cycle time, which itself is very short, created a number of technical problems which are now stated to have been solved satisfactorily by means of mechanical and hydraulic control gear. Agent in this country is Mannex (London), Ltd., 66, Victoria Street, London, S.W.1.



" Pilger " cold reducing machine of 2½in diameter capacity. The machine has a maximum speed of 180 r.p.m. Beyond the crankshaft may be seen the roll frame, while the balancing cranks are in the foreground

Strainer Core Shapes

By the use of strainer cores incorporated in the runners of the mould, the accidental introduction of slag and sand inclusions into the castings is largely avoided, it is claimed, and one source of costly rejects eliminated. The firm A.B. Iföverken, Bromölla, Sweden, has introduced a range of ceramic core shapes which are now available in this country. They are pressure-moulded from a body having a low coefficient of thermal expansion, and are hand fired. As a consequence, they are mechanically strong, erosion-resistant, and non-spalling. The " Cordierite " strainer cores are made in ten standard sizes, eight round shapes ranging from 40mm to 82mm outer diameter, and two rectangular shapes, 88mm by 46mm, and 108mm by 54mm. The plates which are 6mm to 11mm thick, have from eight to twenty-one holes varying between 4·9mm and 7·0mm in diameter. Under metal heads of 6in, the flow of cast iron is stated to vary between 13 and 68 cubic inches per second, according to pattern. The agent for " Cordierite " strainer shapes is Allan Levin, Ltd., 4, Drapers Gardens, Throgmorton Avenue, London, E.C.2.

International Conference on High-Voltage Distribution of Electricity

The Conférence Internationale des Grands Réseaux Eléctriques (C.I.G.R.E.) will hold its sixteenth session in Paris from May 30 to June 9, 1956. In the course of the meetings, which are to be held at the Fondation Berthelot, 28 bis, Rue St. Dominique, Paris (7e), 116 papers are to be given on subjects affecting the production, transformation and distribution of high-voltage electrical energy. Apart from generators, transformers and circuit breakers, the papers will deal with materials for insulation and the construction of overhead transmission lines and underground high-tension cables. Special attention is to be given to problems of circuit protection, relays, stability, current and frequency regulation, and special problems in connection with voltages in excess of 200kV. The previous congress, held in 1954, was attended by 1529 engineers from fifty different countries, and similar interest is anticipated for this year's conference. Application for participation should be addressed to General Secretariat, C.I.G.R.E., 112, Boulevard Haussmann, Paris (9e).

Work of the U.S. Atomic Energy Commission

BY OUR AMERICAN EDITOR

No. II—(*Concluded from page 389, April 20th*)

Army Reactors

THE objective of the army reactors programme of the A.E.C. is the development of land-based package reactor systems suitable for meeting heat and power requirements of the military services in remote areas. The programme now includes two major development projects—the army package power reactor (APPR-1) and the Argonne low power reactor (ALPR). Construction of the APPR-1 plant, which will employ a pressurised water reactor and be capable of producing 1825kW of electricity, was begun at Fort Belvoir, Virginia, on October 5th. Alco Products, Incorporated, is the prime contractor. The completion date of the guaranteed performance lump-sum contract was advanced by five months to July 10, 1957, by contract amendment. Development work supporting military pressurised water reactor systems continued. This work included heat transfer tests at Columbia University, critical experiments at the Oak Ridge National Laboratory and fuel element irradiation tests at Oak Ridge and the National Reactor Testing Station.

In November, a project was established leading to a boiling heterogeneous reactor power plant for military use, having an output of about one-tenth that of the APPR-1. A one year development and engineering design programme was initiated at the Argonne National Laboratory to permit early construction, and the selection of a contractor is in progress.

Preliminary design studies on advanced reactor systems for eventual application to military and civilian use were completed, and materials development work was initiated. The preliminary design of a proposed reactor experiment to give experimental data for incorporation into reactor engineering designs was begun. Conceptual design studies of very small reactor systems to meet additional requirements continued with the completion of a study by the Glenn L. Martin Company, of Baltimore, Maryland. Sanderson and Porter, of New York City, under contract to the Engineer Research and Development Laboratories of the U.S. Army, completed a preliminary design of a small gas turbine power plant suitable for use with a nuclear reactor.

Test Reactors

In August the Commission decided to undertake with Government funds the construction and operation of an engineering test reactor (ETR) at the National Reactor Testing Station where facilities already exist for auxiliary services. Two private-industry proposals to build this reactor were unacceptable to the Government for a number of reasons. For example, both proposals required indemnification by the A.E.C. for personal injuries and property damage arising from atomic hazards which could not be covered by insurance, whereas the Atomic Energy Act would require the owner of the reactor to hold the Government blameless from any damages resulting from the use of special nuclear materials. In addition, both proposals asked that the A.E.C. guarantee payment of percentages of operating costs, including amortisation, and profit to a degree approaching commitments which the Commission would have to make under contracts for the construction and operation of an ETR as a Government facility. Furthermore, the estimated costs to the Government over the periods for which guarantees were requested were substantially in excess of the estimated cost of constructing and operating the ETR next to the materials testing reactor at the National Reactor Testing Station.

An engineering test reactor is urgently needed to provide irradiation facilities for the development of reactor components for military and civilian power reactors. Existing American facilities are not considered suitable for experimental work requiring relatively large spaces in areas with high neutron intensities. The conceptual design of the ETR was prepared by the Atomic Energy Division of the Phillips Petroleum Company. Architect-engineering and construction are being done by the Kaiser Engineers Division of the Henry J. Kaiser Company. The nuclear design of the reactor core and facilities within the tank is being performed by the Atomic Power Equipment Department of the General Electric Company under contract to Kaiser. The overall cost of the reactor is estimated at 15,000,000 dollars, and it is scheduled for completion early in 1957. The core of the ETR will contain a number of experimental holes capable of accepting reactor fuel elements and other components. These holes will range up to 9in square and extend completely through the core and reflector. Nearly all will be provided with facilities outside the reactor tank, such as pumps, heat exchangers, sampling equipment and clean-up systems. These will form loops in which tests may be conducted at temperatures, pressures, and other operating conditions similar to those which the materials undergoing testing might experience in actual reactor applications. The reactor, which is to operate at a power level of 175MW of heat, will be light-water-moderated and cooled, and will be fuelled by uranium enriched in the isotope 235.

The power level of the materials testing reactor at Arco, Idaho, was raised from 30MW of heat to 40MW on September 26th, with a corresponding increase in the usable thermal neutron flux from approximately $3 \cdot 5$ by 10^{14} to $4 \cdot 5$ by 10^{14} neutrons per square centimetre per second, and the reactor has been operated at that level since that time. The increase enables the reactor to handle a greater experimental load by making more high flux space available and, in some cases, shortening irradiation time. The reactor has been operating at capacity, particularly with respect to the experimental holes providing the highest flux. The MTR is used by both the A.E.C. laboratories and private experimenters, with greatest emphasis being placed on experiments furthering the reactor development programme. However, its high flux enables it to produce radioactive isotopes of greater intensity than is possible elsewhere. A contract has been entered into between the Phillips Petroleum Company, which operates the materials testing reactor under contract to the A.E.C., and the Babcock and Wilcox Company for the commercial fabrication of reactor fuel elements on a fixed-price basis. The 325 fuel assemblies covered by the contract price of 90,766 dollars are to be fabricated at a new Babcock and Wilcox works at Lynchburg, Virginia, and the first deliveries are to be made in July. Ultimately, this contract will free the Oak Ridge National Laboratory, which has been providing the fuel assemblies, of a routine manufacturing load, and at the same time will contribute to the development, within private American industry, of skills related to the atomic energy programme.

During August, the Argonne National Laboratory placed into operation a large irradiation facility for studies of the effects of gamma radiation of foods and other materials. The facility utilises spent MTR fuel elements as an intense source on gamma radiation. Twelve elements, each of which provides more than 100,000 curies of radiation, are used. These elements are replaced at frequent intervals in order to maintain a minimum radiation intensity of 1,000,000 röntgens per hour. The facility is available to non-A.E.C. organisations as a part of the programme of providing assistance to industrial concerns, educational institutions, and Government agencies, for the development of peacetime uses of atomic energy. One of the principle users is the U.S. Army Quartermaster Corps which has recently begun a broad study of the sterilisation of food by irradiation.

Education and Training

For some time the Atomic Energy Commission has been concerned with the shortage of engineers, in particular of nuclear engineers, and with the adverse effect the accumulating shortage will have on the development of a large nuclear power industry in the United States. A survey of training and manpower requirements in the atomic energy industry for the next three years was completed last year. Data were collected from 201 industrial concerns having an established or potential interest in atomic power applications and from A.E.C. operations offices and prime contractors. This survey showed that in the next three years in the United States alone there will be an annual demand for approximately 2000 engineers and scientists in the atomic power field. Of these 2000, it is expected that approximately 1200 will already be trained in nuclear technology. There are in the United States approximately 5000 engineers and scientists effectively trained to work in this new industry. Present nuclear educational and training programmes are geared to turn out fewer than 500 engineers and scientists annually. As a consequence, on the basis of the short range requirements alone, there is an immediate need to expand education and training capacity. Recognising this need, the Commission recently adopted policies aimed at helping to expand the capacity of universities and colleges for producing nuclear engineers in particular and thus partially to alleviate the shortage. In the longer range of ten to twenty years, additional educational facilities in this field undoubtedly will be required.

The Commission continued its policy of assisting non-profit-making and educational institutions in the construction and operation of research reactors. This assistance consists of waiving use charges on special nuclear materials and heavy water. In addition, no charge is to be made for special nuclear materials consumed in the operation of research and training reactors. The Commission will also provide funds or services without charge for the fabrication of fuel elements, preparation of fuel solutions and replacement and reprocessing of used fuel elements and neutron sources. The fuel elements of the pool research reactor at the Pennsylvania State University were furnished under this policy. This reactor is now operating at a power level of 100kW and is scheduled to be raised to 1000kW in the near future. The "water boiler" homogeneous reactor at North Carolina State College was out of commission for some time for replacement of the main reactor core vessel, made necessary by corrosion caused by the uranium fuel solution. Repairs have been completed and the reactor is operating again. The University of Michigan is building a pool research reactor and the Massachusetts Institute of Technology has completed the design of a heavy water research reactor.

Although reactors are important training tools, sub-critical reactors, or assemblies, are excellent for many nuclear physics and engineering laboratory experiments. The A.E.C. adopted a policy of assistance to non-profit educational institutions planning to acquire such facilities for training purposes. The assistance available consists of loaning the source material, special nuclear material, or other needed special materials without charge. Such loans are subject to the availability of materials. New York University was the first recipient of such a loan and the sub-critical assembly constructed with the materials loaned was exhibited at the Nuclear Energy Congress in Cleveland, Ohio, during December. The Massachusetts Institute of Technology has also asked for material for such an assembly and requests from other educational institutions are expected.

To assist universities in acquiring qualified staffs to teach nuclear engineering, the Commission has arranged for the School of Nuclear Science and Engineering at the Argonne National Laboratory to hold a special short course for college faculty members this summer. This course will be under the joint sponsorship of the A.E.C., the National Science Foundation, the American Society for Engineering Education, and Northwestern University. Beginning in the

latter part of June and lasting two months, it will include nuclear physics, nuclear engineering, separation chemistry, metallurgy, and other subjects. Sixty faculty members from a number of colleges and universities can be accommodated.

In August eighty-four students were graduated from the 1954–55 session of the Commission's Oak Ridge School of Reactor Technology, a one-year graduate-level course run at the Oak Ridge National Laboratory. Of the fifty-one sponsored students, thirty-three returned to the A.E.C. or to military contractors, and eighteen to the military services and other Government agencies. Of the thirty-three unsponsored students, thirty accepted employment with the A.E.C. or with military contractors, and the other three accepted employment with Government agencies. With the completion of the 1954–55 session the school had graduated 374 men. The 1955–56 session commenced in September with ninety-five students.

Twenty-two American students were among the sixty-two students enrolled in the second seven-month unclassified course in the School of Nuclear Science and Engineering at the Argonne National Laboratory. This training facility was designed originally to fulfil the Government commitments under the International "Atoms-for-Peace" programme initiated by President Eisenhower.

Physical Research

During the past six months significant progress was made in the use and development of accelerators for research in high-energy physics. At Brookhaven research with the cosmotron increased steadily in scope and the machine is now operating on three shifts, five days per week. A great deal of the research is done by physicists from collaborating universities. A large part of their effort is now devoted to the study of unstable particles, including heavy mesons and hyperons.

The design and construction of the alternating gradient synchrotron at Brookhaven is progressing satisfactorily. The diameter of the magnet ring has been set at 842ft. This dimension will provide an energy of at least 25,000MeV. It is estimated that the maximum attainable energy may reach 33,000MeV if the magnetic properties of the magnet steel can be quality controlled in large-scale production. The most important advance in this programme is the successful operation of the electron analogue. This is an experimental alternating gradient machine which accelerates electrons rather than protons. Built to study orbit dynamics, it is 45ft in diameter, has an aperture of 0·8in square, and has very strong focusing. The operation of the analogue has already provided much experience in the handling of alternating gradient machines and has confirmed the calculation of the characteristic of orbits for the larger machine.

At the University of California Radiation Laboratory in Berkeley the performance of the bevatron was improved significantly as a result of modifications to all of the accelerator components. Additions and improvements were also made to the target area, the beam steering and tracing facilities, and the automatic programming equipment. The most important result of research performed with the bevatron during the past six months was the discovery of the antiproton. The identification of the particle was achieved by a team of physicists composed of Drs. Owen Chamberlain, Emilio Segre, Clyde Wiegand, and Thomas Ypsilantis. The detection of the antiproton fulfils one of the important purposes for which the bevatron was constructed. The existence of antiprotons has been a basic tenet of generally accepted nuclear theory for a quarter of a century. Despite continuing experiments with cosmic rays, however, the particle had not been detected. The long lapse between the prediction of the antiproton and its discovery had brought into question the validity of the most basic concepts of nuclear properties. This elimination of uncertainty about one of the cornerstones of nuclear theory is the discovery's most important aspect. Though the discovery is important for understanding the processes by which atomic energy is released, no practical applications of the antiproton are now foreseen.

The 86in cyclotron at the Oak Ridge National Laboratory has been used in demonstrating that many interesting radioactive isotopes can be produced economically and in large quantities. The unusually large currents of high-energy protons generated in this cyclotron make it an unusually effective machine for the production of certain isotopes which are themselves useful tools in medical and biological research. The cyclotron, which was completed in 1951, produces currents five to ten times larger than those available from other cyclotrons, and in many cases the protons are more effective for isotope production than the deuterons commonly available in other cyclotrons. Hence the isotope production rates are higher and the isotope costs lower.

The production of isotopes in the Oak Ridge National Laboratory cyclotron complements, rather than competes with, isotope production in nuclear reactors. Whereas reactors produce isotopes containing a surplus of neutrons, the cyclotron is especially useful in producing the neutron-deficient isotopes. Since the latter are produced by transmutation from another chemical element, they can usually be chemically separated from the original target material so that the product is of high purity and very high specific activity. High production rates of a number of isotopes have been obtained with the 86in cyclotron, including the following: beryllium 7, fluorine 18, manganese 54, cobalt 57, zirconium 65, cadmium 109, arsenic 74, and gallium 67. The commercial processing and distribution of cyclotron-produced isotopes by the Oak Ridge National Laboratory have been discontinued. The isotopes produced in the cyclotron in the future will be processed and distributed through industrial laboratories. The 86in cyclotron will continue to be available, however, to any qualified group for service bombardments where the machine offers unique advantages and can be used without interference with the research programme.

For a number of years, the Neutron Cross Section Compilation Group at Brookhaven has collected and evaluated the numerous cross sections that are important to nuclear theory and reactor development. The results of this work have appeared in the cross section compilation AECU-2040, published in 1952, together with various supplements. A new edition of the compilation, containing many newly-declassified results regarding fissionable isotopes was prepared last year and distributed at the Geneva Conference on the Peaceful Uses of Atomic Energy. This new edition, BNL-325, also contains data on resonance parameters and inelastic scattering, which did not appear in AECU-2040. Because of the co-operation of other countries, it was possible to prepare in advance an addendum to BNL-325 containing cross sections to be presented at the International Conference on the Peaceful Uses of Atomic Energy, so that the addendum was available for distribution at Geneva. At the Geneva Conference, scientists from a number of countries, including the U.S.S.R., combined their results to obtain a set of world's average cross sections of the fissionable isotopes uranium 233, uranium 235, and plutonium 239. The establishment of these cross sections is an example of the co-operation exhibited at Geneva, and will be of value in unifying reactor calculations throughout the world.

The technique of studying the magnetic deflection of fine beams of atoms has been so perfected that it has become possible to determine the magnetic properties of the nucleus even for radioactive atoms. Among the determinable properties of nuclei are the strengths of their spins and their strengths as magnets. These can be determined in a so-called "atomic beam" apparatus by observing the deflections in magnetic and wireless fields of a beam of atoms emerging from a hot furnace. Such results for radioactive nuclei are of special interest because the spin is one of the quantities determining the probability of radioactive disintegration.

Neutrons, upon striking other nuclei, scatter in various directions. By determining the numbers scattered to different angles away from the original direction, scientists can obtain some insight into the mechanics of the collision process. The distribution is of importance in fast reactors, because if the scattering is predominantly forward, the neutrons are held back less effectively by such collisions than they would be if they were uniformly scattered in all directions. An apparatus has been built by Argonne National Laboratory to collect a large amount of such information, using neutrons at many energies up to an energy of 1·7MeV and with a large variety of scattering materials.

During the Geneva Conference, the chairman of the A.E.C. announced that the United States had under way a long-range research programme to develop the controlled release of energy from atomic fusion. It was emphasised at Geneva and in all subsequent discussions that the programme —called Project Sherwood—is considered a very long-range effort. The major research effort in this field is being carried out at A.E.C. laboratories operated by the University of California at Los Alamos, New Mexico, and Livermore, California, and at Princeton University. In addition, there are smaller projects at Oak Ridge, Tennessee, and New York University. The programmes at Los Alamos and Princeton began in 1951 as experiments to test ideas for the containment and control of thermo-nuclear combustion at temperatures comparable to those of the sun. Previously such temperatures have been achieved on earth only in atomic explosions. Shortly thereafter, a third programme was initiated at Livermore by the University of California Radiation Laboratory. The possibility of tapping this source of energy has long been intriguing to scientists. Some of the problems to be overcome, however, are extremely difficult. One problem is that of heating an appropriate nuclear material, such as deuterium, to temperatures of several hundred million degrees and of confining it at that temperature for a sufficiently long period of time to allow an appreciable portion of the nuclei to fuse together, with the consequent release of energy in the form of energetic neutrons, charged particles and gamma radiation. Once this temperature has been achieved the main problem would be that of getting enough thermo-nuclear energy back from the material to repay the power used to achieve and maintain the high temperature. Although the level of research has been greatly expanded since 1951, the programme is still in the research stage. Many years of intensive theoretical and experimental effort will be required before the first prototype of an operating thermonuclear machine is developed.

Metallurgical Research

Two of the most important metallurgical problems associated with the use of uranium in nuclear reactors are corrosion and the dimensional instability of uranium. Since uranium is highly corrodible and the radioactive fission products must be prevented from entering the reactor system, the uranium fuel is usually clad in a protective jacket. The effectiveness of this jacket, however, can be greatly impaired by dimensional changes in the uranium fuel during use. These changes also reduce the flow in the cooling system of heterogeneous reactors, in which coolants pass through narrow channels past the fuel elements. For these reasons considerable research has been conducted on the dimensional instability of uranium in order to understand the basis of the phenomenon and seek means of minimising or eliminating it. Dimensional changes in uranium can occur as a result of thermal cycling or irradiation with neutrons. The mechanisms of these two effects differ, but both are based on the fact that uranium is anisotropic. This means that at temperatures below 660 deg. Cent. the crystal structure of uranium has different physical properties in the three principal crystallographic directions.

As an indication of thermal cycling effects a polycrystalline rod sample of wrought uranium can extend to about six times its original length when subjected to prolonged cycling between temperatures of 50 deg. and 600 deg. Cent. This increase in length is accompanied by a decrease in diameter and essentially no change in volume. Such effects occur particularly in wrought material because the fabrication process produces a preferred orientation. It has been found that the greater the degree of preferred orientation the greater the unidirectional growth upon thermal cycling.

A less drastic effect of thermal cycling, found particularly with cast uranium, is a roughening

of the surface. It is now known, however, that if uranium is prepared, processed or heat-treated in such a way as to produce a very fine grain structure with completely random orientation, neither axial growth nor surface roughening will occur upon thermal cycling. It has been found that the addition of small amounts of certain alloys of about 1 per cent by weight can produce an indirect effect on the thermal cycling behaviour of uranium by influencing its grain size. A single-grain sample of uranium does not undergo dimensional changes upon thermal cycling. Several mechanisms have been proposed to explain thermal cycling effects based on the interactions of grains in the polycrystalline metal and the anisotropy of uranium. Although a great deal of progress has been made in understanding the effects of thermal cycling, a completely satisfactory theory for the phenomenon has not yet been developed and work on this continues.

When a single crystal of uranium is irradiated by neutrons it progressively elongates in one (010) crystallographic direction, shrinks in a second (100) direction and remains unchanged in the third (001) direction. At 100 deg. Cent. this dimensional instability involves an extension of about 50 per cent after sufficient irradiation to cause fission of 0·1 per cent of the uranium atoms. The volume changes accompanying this phenomenon are negligible. When polycrystalline rod samples with a high degree of preferred orientation are irradiated it has been found that the rate of growth may be as much as twice that of a single crystal. It is also known that in such rods, other things being equal, the rate of linear growth upon irradiation becomes greater with increasing cold work and with decreasing grain size.

Irradiation can also produce a roughening of the surface. Caused by the individual grains growing in different directions, this is most noticed in coarse-grained samples. A third kind of dimensional change is due to an increase in volume. This effect is much smaller in magnitude than irradiation or thermal cycling extension. It consists of an increase in volume of the order of 1 per cent after 0·1 per cent of the uranium atoms have fissioned, as compared to a possible 100 per cent increase in length of a highly orientated polycrystalline sample for the same irradiation. This change is thought to be due to internal porosity in addition to the extra volume of fission product atoms, as the latter does not quantitatively account for the effect.

As a result of these studies several means of decreasing or eliminating the dimensional changes of uranium under irradiation have been developed. Fabrication techniques and heat-treatments are used to control the grain size and obtain a random orientation of the grains. Dimensional stability can also be greatly enhanced by suitable alloying. Additions of chromium, molybdenum, niobium and zirconium alone and in combinations can refine and "randomise" the grain structure through heat-treatment with a resultant improvement of stability. By using still greater amounts of these alloying elements a crystal modification can be obtained at room temperature which has excellent dimensional stability under irradiation. Of the several mechanisms which have been advanced to explain the growth of uranium under irradiation, a very promising explanation is based on the anisotropic diffusion of displaced atoms and vacancies produced in the lattice by irradiation and fission. The theory advances the idea that the displaced uranium atoms diffuse preferentially in the (010) lattice direction, thus causing growth in that direction. The theory predicts several causes of the effect and these, as well as other theories, are being checked by further electron microscope examination.

The regular array of atoms in a solid is thrown into disorder by fast particle bombardment, but much of the disorder is thermally unstable even at low temperatures. To understand the detailed nature of the disordering process it is necessary to examine both the nature of the unstable disorder and the annealing process in which order is restored. To this end an experimental facility for the irradiation of solids at temperatures in the neighbourhood of 20 deg. Kelvin (−253 deg. Cent.) has been installed near the centre of the graphite reactor at Oak Ridge. The facility consists of a refrigerated specimen chamber which is cooled by a helium refrigerator. The rate of disordering in specimens held in the reactor at a temperature of 20 deg. Kelvin has been measured for a number of metals and alloys using the change of electrical resistivity as an index of lattice damage. The electrical resistivity of the metal is known to increase with the lattice. It was found that there is apparently a wide variation in both the disordering rate and the thermal stability of lattice disorder for the metals studied. The order of their increasing rates of resistivity change is: gold, copper, brass, aluminium, nickel, cobalt, iron, zinc, Cu_3Au (disordered), Cu^3Au (ordered). Appreciable amounts of the increase in resistivity could be eliminated by warming the specimen to room temperature except for iron and zinc, which require higher temperatures.

TABLE I—*Summary of Major Power Reactor Experiments*

Reactor	EBR No. 1	EBR No. 2	HRE No. 1	HRE No. 2	BORAX III[1]	EBWR	SRE
Location	National Reactor Testing Station, Idaho	National Reactor Testing Station, Idaho	Oak Ridge	Oak Ridge	National Reactor Testing Station, Idaho	Argonne	Santa Susana, California
Responsible laboratory	Argonne	Argonne	Oak Ridge	Oak Ridge	Argonne	Argonne	Atomics International
Heat output	1,400kW	62,500kW	1,000kW	5,000–10,000 kW	15,000kW	20,000kW	20,000kW
Generating capacity	150kW	17,500kW	150kW	300kW	2,400kW	5,000kW	7,500kW
Cost, reactor,[2] $ × 1000	2,700	15,300	1,100	1,800	600	3,600	5,300
Cost, programme,[3] $ × 1000	6,000	39,600*	12,800	38,800*	2,800	19,700*	14,400*
Start of construction	1949 (autumn)	1956	1951 (March)	1954 (July)	1954 (Sept.)	1955 (June)	1954 (August)
Reactor critical	1951 (August)	1958	1952 (April)	1956	1955 (June)	1956	1956
Date operation at full power	1951 (Dec.)	1959	1953 (Feb.)	1956	1955 (July)	1956	1957
Reactor outlet temperature	600 deg. Fah.	1,000 deg. Fah.	480 deg. Fah.	570 deg. Fah.	417 deg. Fah.	488 deg. Fah.	960 deg. Fah.
Reactor pressure	about 100 p.s.i.g.	about 100 p.s.i.g.	1,000 p.s.i.g.	2,000 p.s.i.g.	300 p.s.i.g.	600 p.s.i.g.	300 p.s.i.g.
Amount uranium fuel	48 kg	150 kg or 90 kg Pu	3 kg	4 kg	15 kg	4,500 kg	2,100 kg
Enrichment, U-235	about 90 per cent	45 per cent or 24 per cent Pu	about 90 per cent	about 90 per cent	about 90 per cent	1·4 per cent	2·9 per cent
Moderator	None	None	H_2O	D_2O	H_2O	H_2O	Graphite
Coolant	Sodium-Potassium	Sodium	Circ. fuel sol.	Circ. fuel sol.	H_2O	H_2O	Sodium
Control method	Mov. blanket and U-238 rods	Mov. blanket and fuel rods	U conc. and temp. coeff.	U conc. and temp. coeff.	Control rods and chem. soln.	Control rods	Control rods
Steam conditions	400 p.s.i.g. 540 deg. Fah.	1,800 p.s.i.g. 900 deg. Fah.	200 p.s.i.a. saturated	520 p.s.i.a. saturated	300 p.s.i.g. saturated	600 p.s.i.g. saturated	600 p.s.i.g. 825 deg. Fah.

* Cost of programme is estimated total cost for development of concept from July, 1953, to July, 1958.
** Includes turbo-generator supplied by Southern California Edison Company.
[1] Borax III is part of the EBWR programme.
[2] Including building to house reactor and fabrication of fuel elements for first charge but not fissionable material.
[3] Including reactor.

TABLE I—*Summary of Major Power Reactor Experiments—(continued)*

Reactor	LAPRE I	LAPRE II	LAMPRE	OMRE	LMFRE
Location	Los Alamos	Los Alamos	Los Alamos	National Reactor Testing Station, Idaho	—
Responsible laboratory	Los Alamos	Los Alamos	Los Alamos	Atomics International	Brookhaven
Heat output	2,000kW	1,300kW	About 1,000kW	16,000kW	5,000–10,000kW
Generating capacity	None	None	None	None	None
Cost, reactor,[1] $ × 1000	700	100	—	875	—
Cost, programme,[2] $ × 1000	2,200	280	3,000	1,800	10 to 12,000
Start of construction	1955	1955	1958	1956 (Jan.)	—
Reactor critical	1956	1956	1959	1956	—
Date operation at full power	1956	1956	1959	1957	—
Reactor outlet temperature	805 deg. Fah.	600 deg. Fah.	—	530 deg. Fah.	—
Reactor pressure	About 3,900 p.s.i.g.	About 800 p.s.i.g.	—	300 p.s.i.g.	—
Amount uranium fuel	8·4 kg	7·7 kg	Molten Pu. alloy	20 kg	—
Enrichment, U-235	About 90 per cent	About 90 per cent	—	About 90 per cent	—
Moderator	H_2O	H_2O	None	Diphenyl	Carbon
Coolant	H_2O	H_2O	Sodium-Potassium	Diphenyl	Circ. fuel soln. in Bis.
Control method	Control rods and temp. coeff.	Soln. vol., temp. coeff., movable reflect.	Mov. reflect.	Control rods	U conc. temp. coeff., control rods
Steam conditions	3,600 p.s.i.a.	600 p.s.i.a. sat.	None	None	None

[1] Including building to house reactor and fabrication of fuel elements for first charge but not fissionable material
[2] Including reactor.

TABLE II—*Summary of Prototype Power Reactor Plants Proposed*

Company	Westinghouse and Duquesne Light Co.*	Yankee Atomic Electric Co.	Consolidated Edison Co.	Commonwealth Edison and others	Consumers Public Power District	Power Reactor Dev. Co.	Westinghouse and Pennsylvania Power and Light
Location	Shippingport, Pennsylvania	Western Massachusetts	Indian Point, New York	Near Chicago	Nebraska	Detroit Edison Service Area	P.P. and L. Service Area
Type of reactor	Pressurised water (PWR)	Pressurised water	Pressurised water	Boiling water	Sodium-Graphite	Fast breeder	Homogeneous
Thermal power	236,000kW	480,000kW	500,000kW	682,000kW	250,000kW	300,000kW	—
Gross generating capacity	100,000kW	134,000kW	250,000kW**	180,000kW	75,000kW	100,000kW	150,000kW
Amount of fuel	12 tons natural U and 52kg. about 90 per cent U-235	28,800 kg 2·7 per cent	275 kg U and 8,100 kg Th About 90 per cent for U	68,000 kg 1·1 per cent	24,600 kg 1·8 per cent	2,100 kg 20 per cent	— —
Enrichment, per cent U-235							
Moderator	H_2O	H_2O	H_2O	H_2O	Graphite	None	—
Coolant	H_2O	H_2O	H_2O	H_2O	Sodium	Sodium	Fuel solution
Reactor temperature***	540 deg. Fah.	535 deg. Fah.	500 deg. Fah.	480 deg. Fah.	925 deg. Fah.	800 deg. Fah.	—
Reactor pressure	2000 p.s.i.g.	2000 p.s.i.g.	1500 p.s.i.g.	600 p.s.i.g.	300 p.s.i.g.	100–200 p.s.i.g	—
Steam conditions	585 p.s.i.g. saturated	600 p.s.i.a. saturated	420 p.s.i.a. saturated	600 p.s.i.a., 480 deg. Fah.	800 p.s.i.g., 825 deg. Fah.	600 p.s.i.a., 730 deg. Fah.	600 p.s.i.a.
Estimated cost of reactor ****)	$27,700,000	$17,400,000	—	$34,200,000	$13,500,000	$36,000,000	—
Estimated cost of turbo-generating plant	$10,000,000	$16,000,000	—	$10,800,000	$10,800,000	$9,000,000	—
Total estimated plant cost	$37,700,000	$33,400,000	$55,000,000	$45,000,000	$24,300,000	$45,000,000	—
Cost per kilowatt	$370	$246	$230	$250	$320	$540	—
Estimated completion date	1957	1959–60	1960	1960	1958–9	1959–60	1962

* This reactor is being built by the A.E.C.; Westinghouse and Duquesne are prime contractors to the A.E.C.
** Includes 110,000kW of conventional superheating capacity.
*** Average temperature of coolant in reactor.
**** Not including research and development, fabrication of fuel elements for first charge, or nuclear materials. Fuel element fabrication and nuclear materials are included in fuel costs.

Personal and Business

Appointments

MR. ALAN AIKIN has been appointed assistant publicity manager of Hadfields, Ltd., Sheffield.

MR. ARTHUR ELLIOTT has been appointed a director of Precision Rubbers, Ltd., Bagworth, Leicestershire.

MR. J. H. PENNINGTON has been appointed manager of Technical Ceramics, Ltd., Towcester, Northants.

MR. G. C. DUCKETT, A.M.I.E.E., has been appointed general manager of Astral Switchgear, Ltd.

MR. A. J. M. MILLER has been appointed a director of Shaw-Petrie, Ltd., and Clyde Tube Forgings, Ltd.

MR. JOHN A. HOWIE has been appointed deputy managing director of The Lightfoot Refrigeration Company, Ltd.

MR. A. J. DAY has been appointed an executive director of Kirk and Co. (Tubes), Ltd., 74-82, Paradise Street, London, S.E.16.

MR. G. A. G. IVE has been appointed managing director of Radiovisor Parent, Ltd., in succession to the late Mr. E. Harley Bell.

MR. DONALD GOULDING has been appointed head of the export sales department of Winston Electronics, Ltd., Shepperton, Middlesex.

MR. J. B. PEACOCK, A.M.I.Mech.E., has been appointed deputy chief superintendent engineer of Alfred Holt and Co., Liverpool.

SUNVIC CONTROLS, Ltd., Harlow, Essex, states that Mr. W. J. Donnelly has been transferred to the application engineering department.

MR. F. G. COWLEY has been appointed secretary of the Bristol Engineering Manufacturers Association, in succession to Mr. C. O. Worth who has resigned.

SIR PATRICK HAMILTON, Bt., has been appointed chairman of The Expanded Metal Company, Ltd., Burwood House, Caxton Street, London, S.W.1.

MR. VICTOR BRENNER, managing director of Deutsch and Brenner, Ltd., has been elected president of the Birmingham Exchange and Engineering Centre.

MR. P. W. PARISH has been appointed chief designer in the aircraft division of Saben, Hart and Partners, Ltd., 54-56, Old Christchurch Road, Bournemouth.

MR. FRANK CARR, sales manager of the accessories division of Dunlop, Ltd., has been elected president of the Association of Manufacturers and Distributors of Garage Equipment.

MR. J. LAIRD of the commercial research department of the United Steel Companies, Ltd., has been appointed commercial manager of The Workington Iron and Steel Company.

THE MINISTRY OF SUPPLY states that Mr. F. G. R. Cook has been appointed director of R.A.F. fighter aircraft research and development, in succession to Air Commodore Hawkings.

LONDON TRANSPORT announces the appointment of Mr. K. G. Shave, A.M.I.Mech.E., as rolling stock engineer (road services). He succeeds Mr. T. T. Shephard who has retired.

TURNER MANUFACTURING COMPANY, Ltd., Villiers Street, Wolverhampton, has announced the following appointments: Mr. E. Cars, works director, and Mr. B. F. Brown, commercial director.

MR. H. R. BURKINSHAW has been appointed manager of the London office of Edgar Allen and Co., Ltd., 3, St. James's Square, S.W.1. He succeeds Mr. H. R. Beken who has recently retired.

PROFESSOR E. C. ROLLASON is relinquishing the Henry Bell Wortley chair in metallurgy at Liverpool University to take the chair of industrial metallurgy at Birmingham University in September next.

A.E.I. LAMP AND LIGHTING COMPANY, Ltd., Crown House, Aldwych, London, W.C.2, has announced the following appointments of regional managers: Mr. E. J. Melville, southern; Mr. J. M. Anderson, Scotland and Northern Ireland.

THE UNITED STEEL COMPANIES, Ltd., state that Mr. S. R. Howes, general manager of Samuel Fox and Co., Ltd., will retire on June 30th. He will continue as a director. Mr. Howes will be succeeded as general manager by Mr. H. P. Forder.

JOHNSON, MATTHEY AND CO., Ltd., states that Mr. H. J. Taylor has been appointed manager of the Hadyn Park Works, Shepherds Bush, London, W.12, in succession to Mr. A. Godden who has become the company's general production manager.

THE HYMATIC ENGINEERING COMPANY, Ltd., Redditch, Worcs, states that Mr. J. B. Jay, A.M.I.Mech.E., has been appointed manager of its automation division. Mr. F. D. Brownhill, A.M.I.Mech.E., has succeeded him as chief designer.

Mr. L. F. JEFFREY, controller of the East Midlands division of the Central Electricity Authority, has accepted an invitation to serve on the Court of Governors of Nottingham University, and has been appointed to the university's engineering advisory committee.

THE BAIRD AND TATLOCK GROUP states that Sir Bernard Keen and Mr. A. G. P. Powell have been appointed directors of Baird and Tatlock (London), Ltd., and that Mr. W. C. Johnson and Mr. H. N. Ricketts have been appointed directors of Hopkin and Williams, Ltd.

SHEEPBRIDGE STOKES, Ltd., states that Mr. R. D. Millar has been appointed sales representative in the N.W. area. His address is Liverpool Road, Longton, Preston, Lancs (telephone, Longton 2197). Mr. I. S. Horabin has been appointed sales manager of Harold Andrews Sheepbridge, Ltd.

THE GLOBE PNEUMATIC ENGINEERING COMPANY, Ltd., announces the retirement of Mr. Frank Hills, A.M.I.Mech.E., from the position of managing director. Mr. Hills, who has been in the company's service for fifty years, is remaining on the board as consulting technical director. Mr. C. W. B. Tress, who is at present general manager, has been appointed managing director.

HADFIELDS, Ltd., Sheffield, states that Mr. E. W. Colbeck has been appointed managing director of Hadfields Steels, Ltd., and that Major H. G. Freeman, Mr. J. F. Squire and Dr. J. R. Rait, have joined the board of that company. Mr. A. H. Waine has been appointed managing director of Hadfields Forgings, Ltd., and Mr. R. Lamb, Mr. G. Wood, Mr. E. H. Booth, and Mr. J. F. Squire, have joined the board. Major H. G. Freeman has become managing director of Hadfields Foundry and Engineering, Ltd., and Mr. J. F. Squire and Mr. F. A. Bailey have been appointed directors.

Business Announcements

SIR LINDSAY PARKINSON AND CO., Ltd., has moved into new offices at 6, Lambeth Road, London, S.E.1.

ACHESON COLLOIDS, Ltd., announces the formation of a new subsidiary in Holland entitled Acheson Colloiden N.V. A factory is being built at Scheemda, Groningen.

THE BRISTOL AEROPLANE COMPANY OF CANADA (1956), Ltd., has formed a subsidiary entitled Bristol de Mexico, SA de CV, with its headquarters at Mexico City Airport.

THE MARCONI INTERNATIONAL MARINE COMMUNICATION COMPANY, Ltd., has moved its Port Said office to C.T.O. Building, opp. 3H2, Sharia Sultan Hussein, Port Said (telephone, Port Said 781).

THE SOCIETY OF INSTRUMENT TECHNOLOGY has moved to 20, Queen Anne Street, London, W.1. (telephone, Langham 4251). Commander A. A. W. Pollard, R.N., ret., has been appointed secretary.

COMPOFLEX COMPANY, Ltd., has closed its Wimbledon factory and has transferred the plant to its main factory at Huddersfield Road, Oldham. The company's design and development establishment continues at Godalming, Surrey.

Contracts

MATTHEW HALL AND CO., Ltd., Dorset Square, London, N.W.1, has received a contract to the value of £2,000,000 in connection with extensions to the concentrated complete fertiliser plant at Billingham, of Imperial Chemical Industries, Ltd.

DAVY AND UNITED ENGINEERING COMPANY, Ltd., Sheffield, has received a contract from Australian Iron and Steel, Ltd., for roller tables for a new slabbing mill which is being installed at the Port Kembla Works in New South Wales. The contract is valued at about £500,000.

Miscellanea

VEHICLE TEST CENTRE.—During May the first part of an engineering research and test centre being built by Vauxhall Motors, Ltd., at Chaul End, Bedfordshire, is to come into use. It was started last September, and comprises a 340 yard length of simulated Belgian pavé, 285 yards of track with a hard and unevenly rough surface, and a workshop. The second stage of construction will include a 30ft road, more than a mile long, round the entire site, with a quarter-mile brake-testing straight approached by a more-than 180 deg. bend banked at 23 deg., under which will pass an access road, a dust tunnel, a handling-test area, a watersplash and a corrugated "wash-board" road. In the third phase a workshop of 13,500 square feet will be built, together with a circular steering pad, a second "wash-board" of different wave-length, and five gradients varying from 1 in 13·9 to 1 in 2·5. The final part will bring into use a variety of gravel roads and special surfaces.

FILMS ON GAS.—Three films made for the Gas Council by the Film Producers Guild, Ltd., dealing with the sale of gas and gas appliances, were recently shown in London. The films, entitled "Demonstrational Selling," "Showmanship," and "Lost Sales," demonstrate by over-emphasis the value of good salesmanship. These films are available in either 16mm or 35mm sizes.

"NUCLEAR ENGINEERING."—We welcome the appearance of a new monthly journal, *Nuclear Engineering*, the first issue of which was published on April 9th. Its editorial contents includes articles on "The Harwell Reactor School," by Sir John Cockcroft, director of the research group of the U.K. Atomic Energy Authority; on "Power and the Central Electricity Authority," by Mr. J. Eccles, deputy chairman (operations) of the Central Electricity Authority; on "Experimental Reactor Systems," by R. F. Jackson; and on "Fission Product Disposal from Windscale," by P. V. Danckwerts. *Nuclear Engineering* is edited by Mr. E. N. Shaw, B.Sc., and is published by Temple Press, Ltd., Bowling Green Lane, London, E.C.1, the annual subscription rate being 42s.

TRANS-SONIC WIND TUNNEL.—The Royal Aircraft Establishment, Farnborough, has now completed preliminary running on an 8ft by 6ft wind tunnel for testing up to Mach numbers around 1·2. This tunnel is a modified and improved form of the 10ft by 7ft high sub-sonic tunnel, but the main driving motor has been increased from 4000 h.p. to 12,000 h.p., and a ventilated working section added, with an 8000 h.p. blower to recirculate the air extracted. The tunnel can be pressurised up to 3¼ atm to attain high Reynolds numbers in sub-sonic testing, and can be evacuated to pressures as low as one-tenth atmosphere. Direct viewing of a model in the ventilated working section is not possible, and therefore closed-circuit television is used. The models will be mainly of high-tensile steel. Both aerodynamic research and aircraft project testing will be carried out.

LUBRICATION OF TURBINES.—A new edition of the booklet "Turbine Lubrication" is now available on application to P.D. Department, Wakefield-Dick Industrial Oils, Ltd., Grosvenor Street, London, W.1. Steam, water and gas turbines are discussed: oils such as Perfecto L.C., capable of lubricating both bearings and teeth in a geared turbine installation are dealt with, but the author favours the use of separate lubricants where it is possible to incorporate suitable seals between the systems and adequate storage volume. On the subject of gas turbines, the cooling of rolling bearings in aircraft by oil mist and oil jets is compared, and the advantages of synthetic di-ester oils in viscosity index and volatility where operating temperatures range over extremes are shown. It is also stated that synthetic lubricants can prevent surface damage at rubbing speeds of 10,000ft per minute where petroleum lubricants might fail at one-quarter that figure. A more detailed account is given of the lubrication of industrial gas turbines following steam turbine practice. The water turbine is dealt with last and water lubrication of runner bearings and the use of the lubricating oil in the governor system are mentioned.

NORTH-EAST COAST INSTITUTION.—On April 6th, Hans Edstrand Tekn. D. read his paper "Experiments with Tanker Models," before the North-East Coast Institution of Engineers and Shipbuilders. The paper states that a systematic series of tests with tanker models has been carried out at the Swedish State Shipbuilding Experimental Tank for the purpose of investigating the effects of variations in form and proportions on the resistance and propulsive qualities. The parent form adopted was that of a 15-knot, single-screw tanker of 22,000 tons displacement, and the first variables considered were the shape of the forebody sections, the length-breadth ratio and the breadth-draught ratio. Tests indicated that U-form shape is better than V-form for forebody sections and that earlier comparisons may have been influenced by laminar flow. Performance is influenced only to a limited extent by the length-breadth ratio, while the paper states that an increase in the breadth-draught ratio causes greater resistance, but improved propulsive efficiency. It is mentioned that investigations were extended to forms suitable for 40,000 ton displacement tankers and the form with the higher breadth-draught ratio was used as the parent form for a series which involved variation of the block coefficient. The effect of the longitudinal position of the centre of buoyancy was also investigated.

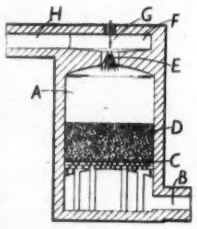
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

GAS PRODUCTION

744,201. August 25 and October 12, 1953.—PROCESSES FOR THE MANUFACTURE OF OIL GAS, Humphreys and Glasgow, Ltd., Humglas House, Carlisle Place, London, S.W.1. (*Inventor: Wilfred Hartley.*)

The invention is concerned with processes for the manufacture of oil gas in which oil and gaseous reactant, generally steam, are brought into contact with a bed or layer of hot refractory material or catalyst in a gas-making chamber. An object of the invention is to ensure that the oil is intimately mixed with the gaseous reactant and is carried on to and into the bed or layer of contact material so that any tendency towards uneven carbon deposition is automatically compensated by the increased gaseous flow towards the more permeable parts of the bed or layer and the resulting increased concentration of carbonaceous residues. Referring to the drawing, the refractory-lined gas-making chamber *A* is vertical and cylindrical, with a rounded upper end and a flat base. A gas outlet connection *B* extends from the chamber near its base and below the level of a perforated support *C* which extends horizontally over the whole cross-section of the gas-making chamber.



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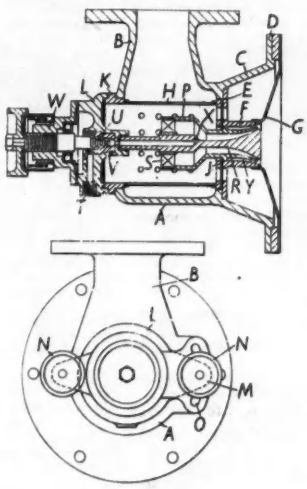
A bed *D* of hot refractory material or catalyst is carried on the perforated support. Extending upwards from the centre of the upper end of the gas-making chamber is a short inlet port *E* which terminates in a horizontal, squat entry chamber *F* of circular cross-section which is of about the same diameter as the gas-making chamber *A*. At the top of the entry chamber *F* and on its axis is an oil spray *G* extending into the inlet port *E* and adapted to provide a cone of oil droplets. An inlet *H* for gaseous reactant into the entry chamber *F* has its axis in the same plane as the entry chamber. As an example of application of the invention to catalytic manufacture of gas from heavy fuel oil and super-heated steam in the apparatus where the gas-making chamber has an internal diameter of some 5ft to 6ft and the rate of injection of gas-making oil is of the order of 2 to 3 gallons per minute with a simultaneous addition of steam superheated to 1100 deg. Fah. and at about 20 lb per minute, a suitable diameter for the axial port is between 20in and 24in. An oil spray giving a cone of oil droplets with an included angle of 45 deg. and 50 deg. and an average diameter of droplets about 100 microns in the vicinity of the opening of the port into the gas-making chamber is then adjusted so that the apex of the cone of oil is at a distance from the opening into the gas-making chamber about equal to the diameter of the opening. The final adjustment is made so that the spray fills as large a proportion of the opening as possible without impingement on the walls of the port, while steam is passing through the port at the required rate into the chamber. Another design for large gas-making chambers is also shown in the specification.—*February* 1, 1956.

BURNERS AND SPRAYERS

744,067. April 22, 1953.—LIQUID FUEL BURNERS, Joseph Lucas (Industries), Ltd., Great King Street, Birmingham, 19. (*Inventors: John Stanley Clarke and Eric Samuel Collinson.*)

Referring to the drawing, the body *A* of a liquid fuel burner is of substantially cylindrical form and has a branch *B* for the air from a blower. At one end of the body is an outlet *C* of truncated conical form, having a flange *D* for attachment to a combustion chamber. In the body and at the junction of the outlet and main portion of the body part is secured a perforated partition plate *E* having a hollow boss *F* extending from its centre into the outlet. Also in the outlet is secured an air swirling plate *G* which is supported by the boss and flange. Within the body is a perforated cylindrical member *H*. At one end this member has secured to it a circular perforated plate *J* adjacent to or in contact with the perforated partition plate *E* for regulating the rate of air flow through the plate. The other end of the member has secured to it a ring *K* which lies between the rear end of the body part and a cover *L* secured to the body by clamping screws *N*. The ring *K* has formed on it a lateral projection *M* through which passes one of the screws *N*, and the range of angular adjustment of the air regulating means is determined by the length of the slots *O* in the cover and body. Within the cylindrical member *H* is supported a sleeve *P* and within this sleeve is a partly hollow axial stem *R*, which at one end is shaped to a conical form so as to form with the sleeve an annular passage for discharge of a mixture of air and liquid fuel, the stem and sleeve forming the fuel-air nozzle. The



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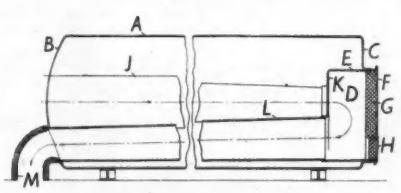
entrance end of the sleeve, which is of larger diameter than the stem has within it an air swirler *S*. Liquid fuel is admitted to the inner end of the stem of the fuel-air nozzle from a supply-pipe connection *T* and the cover also carries an axially adjustable conical plug *U* for regulating the rate of inflow of fuel, the plug being situated within a conical throat piece or seating *V*, and preferably having labyrinth grooves around its periphery. Adjustment of the plug is effected by a manually operable threaded stem engaging a nut *W* in the cover and operable by a knob. The fuel outlets consist of a number of radial ports *X* leading from a bore in the stem *R* to the interior of the sleeve *P*. The arrangement is such that the jets of liquid fuel issuing from the ports *X* in the stem mix with the swirling air in the sleeve and the mixture of fuel and air is discharged in the form of a hollow conical stream through the narrow annular outlet at the discharge end of the fuel-air nozzle. Simultaneously, air from the interior of the perforated cylindrical member *H* flows at an adjustable rate through the partition *E* to the outlet, and after passing through the swirler *G* in the outlet mixes with the fuel-air mixture. Provision is also made for another and smaller air stream to flow from the interior of the member *H* through a narrow annular passage *Y* formed between the sleeve *P* of the nozzle and the boss *F* of the partition. This stream mixes with the fuel-air mixture immediately adjacent to the position at which the fuel-air mixture is discharged.—*February* 1, 1956.

STEAM GENERATORS

745,771. December 16, 1953.—IMPROVEMENTS IN STEAM GENERATORS, Marshall, Sons and Co., Ltd., Britannia Works, Gainsborough. (*Inventor: Dennis Poucher.*)

The invention relates to steam generators of the shell type, such as Cornish and Lancashire boilers. Referring to the drawing, the boiler has a shell *A* with a front plate *B* and a back plate *C*. A dry back combustion chamber *D*, having a cylindrical wall *E*



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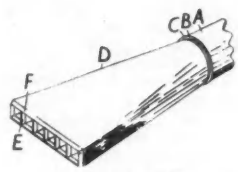
wholly subjected to the boiler pressure, is mounted in the shell *A* and secured to the back plate *C*. The rear end of the combustion chamber *D* is closed by a plate *F* having a firebrick lining *G* and an access door *H*. Two furnace flues *J* pass through the shell from the front plate to the front wall *K* of the combustion chamber and a return flue *L* passes from the wall to the front plate *B* beneath the flues. A main exit flue *M* is joined to the front end of the return flue *L*. The products of combustion from the firebeds pass in the direction indicated by the arrows to the exit flue.—*February* 29, 1956.

JET PROPULSION ENGINES

744,196. August 12, 1953.—SILENCING MEANS, Rolls-Royce, Ltd., Nightingale Road, Derby. (*Inventors: Ferdinand Basil Greatrex and Frederick Reginald Murray.*)

The invention relates in particular to silencing means for the outlets of pipes of jet-propulsion engines, through which the jet gases pass to atmosphere in non-pulsating flow. Its object is to provide a silencing means which is light and simple and in which the pressure losses are small. As shown in the drawing, the downstream part *A* of the jet pipe carrying the exhaust from the jet engine is of circular cross-section and has on its end an annular flange *B* to which is secured by bolts a flange *C* on a second piece of piping or outlet portion *D* which forms the discharge end of the jet pipe. It will be seen that pipe *D* changes gradually from a circular cross-section at its up-stream end to a rectangular cross-section at its downstream end, the length of the rectangular section being approximately six times its width. The transition is made smoothly with substantially no change of cross-section area from the upstream end to adjacent the downstream end. At the downstream end the sides of the rectangle are inclined inwards as shown at *E* to form a throat. This is divided into six substantially separate apertures by struts *F* across the orifice of the pipe, each division



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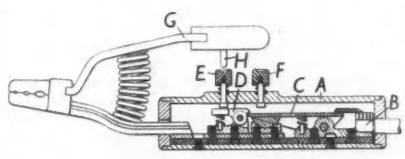
being substantially square in cross-section. The struts are of trapezoidal form and they extend inwards only across the throat portion of the jet. The perimeter of the rectangular downstream end of the jet pipe and the discharge orifice is approximately 1·6 times that of a circular nozzle of the same area. The perimeter is considered as being the wall of the pipe excluding the struts, that is to say, the boundary between the gas stream and the external atmosphere. The lengthwise dimension of the outlet may conveniently be arranged parallel to the trailing edge of the aircraft wing. A modified design is also shown in the specification.—*February* 1, 1956.

WELDING EQUIPMENT

745,681. July 9, 1953.—ELECTRODE HOLDERS FOR WELDING, The Ford Motor Company, Ltd., 88, Regent Street, London, W.1, Francis Laycock, 7, Hamilton Avenue, Romford, and Ernest Frost, 15, Leigham Court Drive, Leigh-on-Sea.

The invention relates to electrode holders for welding and consists of a holder in which release and re-set devices are embodied in the hand grip respectively for breaking the electric supply connection and for ensuring that the connection once broken can only be restored by a positive operation. As described in the drawing, a tubular hand grip *A* is provided at one end with an inside terminal *B* for the electric supply cable, and from this terminal a connection extends to a spring-loaded arm *C* which is normally held down by the hooked end of a further spring-



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loaded arm *D*. Opposite the other end of the arm *D* the spring-loaded release switch push button *E* is mounted so that when depressed it raises the hooked end of the arm to release the arm *C* from its down position and thus breaks the connection with the cable. The released end of the arm *C* comes to rest against the end of the spring-loaded re-set button *F* so that when the button is depressed the electrical connection can be re-set. The free arm of the pincers *G* is arranged so that when depressed to take out an electrode from the pincers or to insert a new electrode it depresses the release button *E* by means of a projection *H*. The safety device can be used in a.c. or d.c. welding supply.—*February 29th*, 1956.

Launches and Trial Trips

CITY OF COLOMBO, cargo liner ; built by Barclay, Curle and Co., Ltd., for Ellerman Lines, Ltd.; length 470ft, breadth 65ft 6in, depth 32ft 6in ; five cargo holds, one 70-ton, two 12-ton, six 10-ton, four 7-ton and four 5-ton derricks, electric deck machinery, one 320kW and two 240kW diesel-driven generators ; Barclay, Curle-Doxford oil engine, arranged to burn heavy oil fuel, six cylinders, 750mm diameter by 2500mm combined stroke. Trial, February 16th.

ZAGORA, cargo ship ; built by the Forges et Chantiers de la Mediterranee for the Compagnie Franco-Cherifienne de Navigation ; length overall 255ft 11in, length between perpendiculars 246ft 1in, breadth moulded 42ft, depth to shelter deck 27ft 1in, maximum summer draught 18ft ½in, deadweight 2400 tons, gross tonnage 1450, service speed 13·5 knots, Nordberg twelve-cylinder diesel engine. Trial, February.

JEAN BART, tug ; built by the Ateliers et Chantiers de France for the Societe Dunkerquoise de Remorquage et de Sauvetage ; length overall 172ft 7in, length between perpendiculars 157ft 6in, breadth moulded 31ft 10in, depth 16ft 1in, draughts 13ft 9½in forward, 16ft 5in aft, displacement 1500 tons, trial speed 15 knots ; 35-ton towing winch, three 55kW diesel-driven generators; two Werkspoor four-stroke, single acting diesel engines, total power 2500 h.p. at 325 r.p.m. drive single shaft through three speed reduction gear at 180/160/146 r.p.m. Trial, February.

MICHAEL C, cargo ship ; built at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd., for Andria Maritima S.A., Panama ; length between perpendiculars 435ft, breadth moulded 60ft, depth moulded to shelter deck 39ft, five cargo holds, one deep tank, one 30-ton, one 3-ton, four 5-ton and six 10-ton derricks ; steam deck machinery ; one 50kW diesel-driven generator ; Swan; Hunter-Doxford oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4400 b.h.p. at 115 r.p.m., two multitube boilers. Launch, March 26th.

CAMITO, passenger and banana carrier ; built by Alexander Stephen and Sons, Ltd., for Elders and Fyffes, Ltd.; length between perpendiculars 415ft, breadth moulded 62ft, depth to upper deck 34ft 9in, 103 passengers in cabins, 20 deck passengers, two sets of double reduction geared turbines, steam supplied at 510 lb per square inch and 750 deg. Fah. by three Babcock and Wilcox boilers. Launch, March 27th.

ANNAHDA, grab hopper dredger ; built by Henry Robb, Ltd., for the Crown Agents for Overseas Governments and Administration ; length overall 110ft., breadth moulded 29ft, hopper capacity 5500 cubic feet on 9ft mean draught, loaded speed 8·5 knots; one Priestman diesel grab dredging crane, grabbing radius 30ft, working depth 50ft, one 70 cubic feet mud grab, one 55 cubic feet sand grab, one 32 cubic feet rock grab ; two 15kW diesel-driven generators ; one Crossley two-stroke diesel engine, 420 b.h.p. at 340 r.p.m. Launch, March 27th.

ROWANMORE, cargo ship ; built at Govan by Harland and Wolff, Ltd., for the Johnston Warren Lines, Ltd.; length between perpendiculars 435ft, breadth moulded 63ft, deadweight 11,000 tons on 27ft 6in draught, four cargo holds, one set of deep tanks, one 50-ton, four 10-ton and twelve 5-ton derricks, steam deck machinery ; three 50kW steam-driven generators, three thimble-tube boilers ; Harland and Wolff single-acting, two-stroke, opposed-piston oil engine, four cylinders, 750mm diameter by 2000mm combined stroke, 110 r.p.m. Launch, March 27th.

CRYSTAL GEM, bulk sugar carrier ; built by Hawthorn Leslie (Shipbuilders), Ltd., for the Sugar Line, Ltd.; length between perpendiculars 430ft, breadth moulded 61ft, depth moulded to upper deck 37ft 3in, deadweight 9750 tons, draught 24ft 6in, service speed 12 knots ; five holds, wing spaces for water ballast and oil fuel ; one 25-ton and ten 10-ton derricks, steam deck machinery ; two 75kW diesel-driven generators, one 20kW steam-driven generator ; Hawthorn-Doxford oil engine, four cylinders, 600mm diameter by 2320mm combined stroke, 3300 b.h.p. at 108 r.p.m. Trial, March 27th.

REDCAR, ore carrier ; built by Smith's Dock Company, Ltd., for the North Yorkshire Shipping Company, Ltd.; length overall 505ft, length between perpendiculars 480ft, breadth moulded 68ft 9in, depth moulded 36ft 3in, deadweight 15,400 tons on 28ft 11in draught, service speed 11·5 knots ; four main cargo holds, wing tanks for water ballast, one dry cargo hold, MacGregor single-pull hatch covers, two 5-ton and one 3-ton derricks, steam deck machinery ; two 75kW steam-driven and one 75kW diesel-driven generators, two 600 tons per hour main ballast pumps ; Hawthorn-Doxford two-stroke oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4450 b.h.p. at 115 r.p.m., two Scotch marine boilers. Trial, March.

Catalogues and Brochures

LANCASHIRE DYNAMO AND CRYPTO, Ltd., Trafford Park, Manchester, 17.—Illustrated brochure dealing with a range of flameproof motors and alternators. Illustrated brochure dealing with a range of synchronous and induction motors used in collieries.

WHESSOE, Ltd., 25, Victoria Street, London, S.W.1.—Folder dealing with advanced designs in welded platework giving methods of inspection of shop and site built vessels.

SERVOMEX CONTROLS, Ltd., Crowborough Hill, Jarvis Brook, Sussex.—General catalogue dealing with "Servomex" voltage stabilisers and high precision motor controllers.

FOLLSAIN-WYCLIFFE FOUNDRIES, Ltd., Lutterworth, nr. Rugby.—Brochure dealing with heat-resisting castings in "EV" heat resisting steel and "Wynite" heat-resisting cast iron.

THE GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, London, W.C.2.—Brochure dealing with industrial selenium rectifier equipment showing an illustrated range.

LONDEX, Ltd., Anerley Works, 207, Anerley Road, London, S.E.20.—List No. 172 giving details of electronic counter and batch counter dealing with their applications and construction.

EVANS ELECTROSELENIUM, Ltd., 110, Potter Street, Harlow, Essex.—Leaflet giving details of "EEL" B.R.S. daylight factor meter dealing with its construction, operation and application.

CHARLES WINN & CO., Ltd., Granville Street, Birmingham, 1.—Booklet S.M.1, dealing with a standard range of screwing and cutting machines for tubes, bends, nipples, bolts, rods and fittings.

THE VARLEY MAGNET COMPANY, Cambridge Row, Burrage Road, Woolwich, S.E.18.—Leaflet dealing with S.M.O. miniature solenoid developed for the electronic and accounting machine industry.

THE ENGLISH SALVI COMPANY, Ltd., 11, Kensington Church Street, London, W.8.—Descriptive folder and price list dealing with "Salvi" hydraulic compressor for overhead electric power line joints.

STARTRITE ENGINEERING COMPANY, Ltd., Waterside Works, Gads Hill, Gillingham, Kent.—Leaflets giving details of "Startrite" Bantam drills designed to cover the full range of drilling operations.

WESTINGHOUSE BRAKE & SIGNAL COMPANY, Ltd., 82, York Way, King's Cross, London, N.1.—Illustrated catalogue dealing with signalling equipment giving description and ordering particulars.

E. BOYDELL AND CO., Ltd., Old Trafford, Manchester, 16.—Brochure illustrating the "Muir-Hill 2-WL" 1 cubic yard hydraulic loader with suspension system providing safety margins with high output.

THE FLEXOTHENE DIVISION OF VITALOID PRODUCTS (MANCHESTER), Ltd., 11, Duke of York Street, St. James's, London, S.W.1.—Illustrated folder dealing with a packaging material, called "Flexothene."

F. BRAUER, Ltd., Grove Road, Harpenden, Herts.—Illustrated catalogue and price list describing "Brauer" quick action toggle clamps used in drilling, reaming, milling, welding, gluing and bonding or assembling.

LAFARGE ALUMINOUS CEMENT COMPANY, Ltd., 73, Brook Street, London, W.1.—Leaflet dealing with foundry floors in refractory concrete used where radiant heat or spillage of molten material is encountered.

B.E.N. PATENTS, Ltd., P.O. BOX No. 10, High Wycombe, Bucks.—Leaflet dealing with model 310 air motor agitator designed to fit standard B.E.N. pressure material containers of 3, 5 and 7 gallon capacity.

HALL AND HALL, Ltd., Oldfield Works, Hampton, Middlesex.—Folder dealing with "Hallite" rubber waterstops designed for use in reservoirs, sea defence walls, sewage works, water towers, culverts, dams and canal floors.

THE BELMOS COMPANY, Ltd., Bellshill, Lanarkshire.—Leaflets Nos. K112, K710 and L7, dealing with type DIF.600 hand-operated air-break circuit breaker, remote control stations and type PF console for power factor correction relays.

THE GENERAL ELECTRIC COMPANY, LTD., OF ENGLAND, Fraser & Chalmers Engneering Works, Erith, Kent.—Brochure entitled "Heavy Duty Idlers" giving detail dimensions and technical descriptions of types of idelr in the 6in heavy duty range.

LAFARGE ALUMINOUS CEMENT COMPANY, Ltd., 73, Brook Street, London, W.1.—Leaflet giving, details of monolithic underground flues in refractory concrete for use in the iron and steel industry, ferrous and non-ferrous foundries, brick industry, ceramic and glass industry, &c.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Tues., May 1st.—OXFORD, READING AND DISTRICT BRANCH : University Letters Lecture Theatre, London Road, Reading, Annual District Meeting, 6 p.m.

Wed., May 2nd.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, Film Show, 7.30 p.m.——PRESTON BRANCH : Chamber of Commerce, 49A, Fishergate, Preston, "Ventilation in Industry," R. W. James, 7.30 p.m.

Fri., May 4th.—LIVERPOOL BRANCH : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, "Underfloor Duct System," W. J. Mann, 7.30 p.m.

ELECTRICAL ASSOCIATION FOR WOMEN

Tues. to Thurs., May 1st to 3rd.—Llandudno, Thirty-First Annual Conference.

ILLUMINATING ENGINEERING SOCIETY

To-day, April 27th.—BIRMINGHAM CENTRE : "Regent House," St. Phillip's Place, Colmore Row, Birmingham, "Blackpool Illuminations," H. Carpenter, 6 p.m.

Thurs., May 3rd.—NOTTINGHAM CENTRE : E. Midlands Electricity Board, Smithy Row, Nottingham, Annual General Meeting and Brains Trust, 6 p.m.

INCORPORATED PLANT ENGINEERS

Tues., May 1st.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, Strand, W.C.2, "Repairs of Cracked Castings—The Modern Methods," N. Tinwell, 6.30 p.m.

Wed., May 2nd.—LEICESTER BRANCH : College of Art and Technology, The Newarkes, Leicester, "Flexible Coupling," 6.30 p.m.——SOUTHERN BRANCH : Polygon Hotel, Southampton, Talk by J. P. M. Pannell, 7.30 p.m.

Thurs., May 3rd.—PETERBOROUGH BRANCH : White Lion Hotel, Church Street, Peterborough, Members' Ten-Minute Papers, 7.30 p.m.

Tues., May 8th.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "Mechanical Handling," Film, 7.15 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Sat., April 28th.—BRISTOL AND WEST OF ENGLAND BRANCH : Grand Hotel, Bristol, Annual General Meeting, 3 p.m.

Tues., May 15th.—COVENTRY SECTION : Room A5, Technical College, Coventry, "Investment Casting for Aircraft Engines," D. F. B. Tedds, 7.30 p.m.

INSTITUTE OF FUEL

Tues. and Wed., May 1st and 2nd.—Church House, Westminster, London, S.W.1, Opening Conference of a Special Study of "Domestic Heating in the United Kingdom—Present and Future," 10 a.m.

INSTITUTE OF NAVIGATION

Wed., May 16th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, The James Cook Exhibition at Greenwich, G. P. B. Naish, "Ballooning," C. H. Gibbs-Smith, D. N. Harrison, and C. S. Durst, followed by a Discussion, 5 p.m.

INSTITUTE OF PHYSICS

Frl., May 4th.—NON-DESTRUCTIVE TESTING GROUP : 47, Belgrave Square, London, S.W.1, a Symposium on "Principles of Penetrant Methods," H. L. Carson, W. G. Cook and R. Schnurmann, 6.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., April 30th.—N. REGIONAL CENTRE : Victoria and Station Hotel, Preston, Centre Annual General Meeting, 7.30 p.m.

Tues., May 1st.—E. MIDLANDS CENTRE : Mechanics' Institute, Nottingham, Centre Annual General Meeting, 7.30 p.m.

Wed., May 2nd.—W. REGIONAL CENTRE : Adelphi Hotel, Lime Street, Liverpool, Centre Annual General Meeting, 7.30 p.m.

Fri., May 11th.—S. WALES GROUP : S. Wales Institute of Engineers, Park Place, Cardiff, "The Commer 'T.S3' Two-Stoke Diesel Engine," E. W. Coy, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

To-day, April 27th.—YORKSHIRE ASSOCIATION : Royal Victoria Hotel, Sheffield, Annual General Meeting, 6.15 p.m.

Tues., May 1st.—HYDRAULICS MEETING : Great George Street, Westminster, London, S.W.1, "Pumping Problems : Present and Future," Herbert Addison, 5.30 p.m.

Thurs., May 3rd.—N.W. ASSOCIATION : Engineers' Club, Albert Square, Manchester, Annual General Meeting, 6.30 p.m.

Tues., May 8th.—PUBLIC HEALTH MEETING : Great George Street, Westminster, London, S.W.1, "The Construction of Middleton Connecting Sewer in North Manchester," E. H. Collier, 5.30 p.m.——NORTHERN COUNTIES' ASSOCIATION : Neville Hall, Newcastle upon Tyne, 1, Students' Annual General Meeting, followed by Films, 6.15 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, April 27th.—JOINT MEETING : Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, Graham Clark Lecture, "The Impact of Engineering on Society," Sir Maurice Bowra, 5.30 p.m.

Tues., May 1st.—MEASUREMENT AND SUPPLY SECTIONS : Savoy Place, London, W.C.2, Discussion on "Methods of Fault Detection and Location in Impulse Tests on Transformers," opened by F. S. Edwards, 5.30 p.m.——N. MIDLAND CENTRE : Central Electricity Authority, 1, Whitehall Road, Leeds, 1, Annual General Meeting, 6.30 p.m.

Wed., May 2nd.—S.W. SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Annual General Meeting, "The Recent Search for and Salvage of the 'Comet' Aircraft near Elba," C. G. Forsberg and G. G. Macneice, 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, April 27th.—JOINT MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, Graham Clark Lecture, "The Impact of Engineering on Society," Sir Maurice Bowra, 5.30 p.m.

Tues., May 1st.—JOINT MEETING : Institution of Civil Engineers, Great George Street, London, S.W.1, "Pumping Problems, Present and Future," Herbert Addison, 5.30 p.m.

Fri., May 4th.—GENERAL MEETING IN CONJUNCTION WITH THE HYDRAULICS GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "Three-Dimensional Motion in Axial-Flow Impellers," S. P. Hutton, "Performance of an Axial-Flow Pump," E. A. Spencer, 5.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS AND INSTITUTE OF MARINE ENGINEERS

Sat., April 28th.—SOUTHERN JOINT BRANCH : Visit to Cowes, including a paper, "Shipbuilding at Cowes," J. A. Milne, 2 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Mon., May 7th.—ORDINARY MEETING : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "An Introduction to Microwaves and Wave-Guide Transmission," C. F. Floyd, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., May 2nd.—EASTERN REGION : Works visit to the Cliff Quay Works, Ipswich, of Fisons, Ltd., 7.30 p.m.

Sat., May 5th.—NOTTINGHAM SECTION : Works visit to Crossley Premier Engines, Ltd., Sandiacre, 10 a.m.

Tues., May 8th.—BIRMINGHAM GRADUATE SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, Film Evening, 7 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, April 27th.—Connaught Rooms, Great Queen Street, Kingsway, London, W.C.2, Annual Dinner, 6.45 p.m.

Wed., May 2nd.—MIDLAND SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Electronic Control—The New Power in Industry," John A. Sargrove ; Film, "The First Automatic," 7 p.m.

ROYAL AERONAUTICAL SOCIETY

Wed., May 9th.—ALL-DAY SECTION LECTURE ON SUPERSONIC FLIGHT : Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "Propulsion," A. V. Cleaver ; "Aerodynamics," P. J. Duncton ; "Structures," D. J. Farrar ; "Cabin Conditions, Controls, &c.," H. H. Gardner, 10 a.m.

SOCIETY OF ENGINEERS

Mon., May 7th.—Geological Society, Burlington House, Piccadilly, London, W.1, "Oil-Fired Packaged Portable Boilers," D. F. Brice, 5 p.m.